FINAL REMEDIAL DESIGN REPORT
FINAL REMEDY

AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

Prepared For:

ACS RD/RA Group

Prepared By

Montgomery Watson
2100 Corporate Drive
Addison, Illinois 60101

August 1999

MONTGOMERY WATSON

MONTGOMERY WATSON

August 20, 1999

Mr. Kevin Adler
Remedial Project Manager
U.S. Environmental Protection Agency
Region V, SR-6J
77 West Jackson Boulevard
Chicago, IL 60604-3590

Re: Final RD Report
ACS NPL Site, Griffith, Indiana

Dear Mr. Adler:

On behalf of the ACS RD/RA Group, Montgomery Watson is pleased to submit three copies of the Final RD Report for the Final Remedy at the ACS NPL Site. For ease of review, we have also enclosed a red-line/strike-through version of the document, which shows the applicable changes we made, based on the Agency comments. An annotated response to Agency comments is also enclosed as Appendix G of the Final RD.

If you have questions or require additional information on the Final RD, please contact me at (630) 691-5045.

Sincerely,

MONTGOMERY WATSON

Thomas A. Blair

Thomas A. Blair, P.E.
Project Manager

cc: Sean Grady, IDEM - 3 copies
Steve Mrkvicka, Black & Veatch – 3 copies
Joseph D. Adams, Jr. – 1 copy
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Montgomery Watson
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Addison, Illinois 60101

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly Registered Professional Engineer under the laws of the State of Indiana.

Signature: Thomas A Blair

Name: Thomas A. Blair, PE

Date: 8/19/99 **Reg. No.:** 9600462

My registration expires July 31, 2000

EXECUTIVE SUMMARY

The American Chemical Service, Inc. (ACS) Site is a 33-acre parcel of land, including a currently active chemical manufacturing plant located at 420 South Colfax Avenue in Griffith, in the northwest corner of Indiana. The Site began reclaiming spent solvent in 1955 and continues to manufacture specialty chemicals. Based on the findings of an RI/FS and subsequent studies and groundwater sampling, four primary contaminant source areas have been identified at the Site: the On-Site Containment Area (ONCA), the Still Bottoms Pond Area (SBPA), the Off-Site Containment Area (OFCA) and the Kapica-Pazmey (K-P) Area. Identified contaminants of concern include volatile organic compounds ("VOCs") in the soil and groundwater and PCBs in the soil. This Site was placed on the National Priorities List in 1984 and a Record of Decision ("ROD") was issued on September 30, 1992. The ROD specified groundwater pump-and-treat, low temperature thermal treatment ("LTTT") of buried waste and contaminated soils, in-situ vapor extraction ("ISVE") of contaminated soils, drum removal from the ONCA, and groundwater monitoring for remedial action at the Site. An alternate remedy was presented in the Conceptual Work Plan (Montgomery Watson, August 1998) and 30% Remedial Design Report, *Alternative Remedy, ACS NPL Site (Montgomery Watson, February 1999)*. The alternate remedial action (Final Remedy) presented in these reports replaces the LTTT with a more extensive containment and ISVE application that meets the overall objectives for the remedy and is more technically feasible and cost effective than the LTTT approach (ROD Remedy). The ROD will be amended in May 1999 to reflect changes of the original ROD Remedy to the Final Remedy.

Groundwater pump-and-treat and groundwater monitoring have already been implemented to some extent at the Site. In addition, a polyethylene and bentonite slurry containment barrier was constructed around the Site source areas. One foot of clay cover has also been placed on the OFCA. These containment measures effectively isolate the source areas from further off-site migration of contaminated groundwater. In response to the ROD requirement for LTTT, a materials handling and LTTT study were undertaken to determine the feasibility of LTTT at the Site. The results of the materials handling study showed that less than 50% of the buried waste and soil at the Site are amenable to a thermal remedy. The results of the LTTT study determined that even though LTTT can be effective at treating organic compounds, implementing the technology at the ACS Site would be extremely difficult and risky based on complications with buried debris, municipal waste, fugitive vapor loss, and potential for explosions during excavation and treatment. Therefore, an alternate to manage the organics at the Site needed to be developed.

The Final Remedy described in this Final Remedial Design Report (FinalRD) incorporates the groundwater pump-and-treat and ISVE requirements of the ROD, and will meet the general remedial objectives of the ROD. The Final Remedy includes the following components:

- Enhancement of the current containment systems in the SBPA, OFCA, and K-P Areas by covering each area to reduce infiltration and prevent direct contact with contaminants.

- Mass removal of mobile VOC contaminants through the use of ISVE in the SBPA, the OFCA, and the K-P Area.

- Elimination of a primary potential source of contaminants by excavating drums from the ONCA and disposing of the contents off-site in accordance with the Agency-approved January 1999 Buried Drum Removal Work Plan as revised by the January 26, 1999 Montgomery Watson response to Agency comments.

- Removal of the PCB-impacted sediments in the wetlands area by excavating and disposing sediment off-site at a TSCA-approved landfill or consolidating them on-site in a contained area depending on contaminant concentrations in accordance with the April 1999 PCB Sediment Excavation and Wetlands Restoration Work Plan.

- Continued operation of the groundwater pump and treat system. The existing Groundwater Treatment Plant will be expanded during 1999 to treat increased contaminant loading from the Site dewatering activities, and the ISVE condensate.

- Active treatment and monitored natural attenuation (MNA) to address contaminated groundwater outside of the barrier wall to the north and south of the Site.

Application of ISVE to remove VOC contaminants will be initiated in the OFCA and the K-P Area, where there is sufficient vadose zone to implement ISVE. In addition, the water table will be lowered in these areas while the ISVE system is running to expose additional contaminants to the ISVE and thereby increase the mass of VOCs removed. A phased approach to ISVE start-up will be implemented, so that the vapor treatment system for the ISVE system can be optimized and operated as efficiently as possible. Once the ISVE system is optimized with the lowered water table in the OFCA and K-P Areas, the ISVE system will be applied to the SBPA. The water table will also be lowered in this area to increase the effectiveness of the ISVE application. Again, a phased approach to start-up will be conducted to maximize the treatment system efficiency and optimize contaminant recovery. Discrete areas of contamination below the lowered water table in the SBPA and OFCA, where dewatering for treatment would not be efficient, will be treated by air sparging.

The SBPA, the OFCA, and the K-P Area will be covered with a low permeability cover material that will provide a surface seal for the ISVE system, reduce infiltration of rainwater, and prevent direct contact with exposure to contaminants and vapors from the contaminants in those areas. The initial cover layers will be installed as part of the start-up of the ISVE systems. Once the ISVE systems are in place and have been optimized, the final layers of the covers will be installed.

The ISVE system will then continue to be applied to the SBPA, OFCA, and the K-P Area, until air vapor samples indicate that the applicable shut down criteria have been reached. Pulsing and other optimization efforts will be conducted to maximize efficiency and minimize supplemental fuel use, reducing the total emissions from the off-gas treatment system(s).

Coordination of the remedial actions with the ongoing ACS, Inc. chemical plant operations will be required as long as the chemical plant continues to operate on-Site. The chemical plant currently uses the SBPA and several adjacent areas, which will be covered and treated with ISVE, for access and transfer operations. The need to modify the remedial actions to accommodate continued operation of the plant may result in modified work schedules and costs.

The Final Remedy is a robust system, capable of complying with the ROD objectives for remedial action at the Site. The combination of continued groundwater pumping and treatment, covering source areas for containment, ISVE for source reduction, active treatment and MNA for groundwater, and source removal in the ONCA and wetland, will adequately address the risks at the Site. Upgrade of the groundwater treatment plant is required in order to treat the water from dewatering activities and condensate from the ISVE system. Those upgrades are currently ongoing and are being completed on a design/build basis. IDEM permitting departments and U.S.EPA have been contacted and are aware of these ongoing upgrades. The detailed design of these upgrades is outside the scope of this document and is not presented herein. The relevant information from this design document (ISVE condensate flows, groundwater pumping rates, contaminant loads, etc.) has been taken into account in the design of the groundwater treatment plant upgrades.

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ACRONYMS

ACS, Inc.	American Chemical Service, Inc.
BVSPC	Black & Veatch Special Projects Corporation
BWES	barrier wall extraction system
CBR	California Bearing Ratio
Cy	cubic yard
DNAPL	dense non-aqueous phase liquid
EAL	equivalent axle load
EPA	Environmental Protection Agency
FS	Feasibility Study
FML	Flexible Membrane Liner
gpm	gallons per minute
GWTP	groundwater treatment plant
HDPE	high density polyethylene
IAS	in-situ air sparging
IDEM	Indiana Department of Environmental Management
ISVE	in-situ soil vapor extraction
K-P	Kapica-Pazmey
LNAPL	light non-aqueous phase liquids
LTTT	low temperature thermal treatment
MNA	monitored natural attenuation
NCP	National Contingency Plan
OFCA	Off-Site Containment Area
ONCA	On-Site Containment Area
ORC®	Oxygen Release Compound®
PCB	polychlorinated biphenyls
PGCS	perimeter groundwater containment system
ppm	parts per million
PSVP	Performance Standard Verification Plan
RD	remedial design
RI	remedial investigation
ROD	Record of Decision
ROI	radius of influence
SBPA	Still Bottoms Pond Area
scfm	standard cubic feet per minute
SOW	Statement of Work
SVOC	semi volatile organic compounds
UV	ultra-violet
USACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
VFPE	very flexible polyethylene
VOC	volatile organic compounds
WDNR	Wisconsin Department of Natural Resources

1.0 INTRODUCTION

This document presents the Final Remedial Design (Final RD) for the Final Remedy at the American Chemical Service (ACS) Site (Site). The Final Remedy is being implemented on a design-build format. Due to the nature of the design-build format, the level of detail necessary to implement the design is not as extensive as that of a typical design-procure-build format. This Final RD presents the information submitted with the May 1999 95% RD (24) with revisions based on the June 16, 1999 Black & Veatch Special Projects Corporation (BVSPC) comments (on behalf of the United States Environmental Protection Agency (U.S. EPA)) (25) and the July 8, 1999 Indiana Department of Environmental Management (IDEM) comments (26). An annotated response to comments is included as Appendix G (27).

The Final RD contains the required information needed for a design-build format and consists of this text description and the design or drawings (Drawings) included in Appendix A. This Remedial Design should be used in conjunction with the following work plans, submitted in June 1999: Performance Standard Verification Plan, Construction Quality Assurance Plan, Field Sampling Plan Addendum, Site Safety Plan Addendum, and Contingency Plan.

The ACS Site is a 33-acre parcel of land, including an active chemical manufacturing plant located at 420 South Colfax Avenue in Griffith, in the northwest corner of Indiana. The Site was placed on the National Priorities List in 1984 and a Record of Decision (ROD) was issued on September 30, 1992. The ROD required treatability studies and indicated Low-Temperature Thermal Treatment (LTTT) would be used for treatment of buried waste in the Off-Site Containment Area (OFCA) and for volatile organic compounds (VOC) contaminated soil unable to be treated by in-situ soil vapor extraction (ISVE). The results of the 1997 Material Handling and LTTT treatability studies (1,2) showed that LTTT treatment would not safely achieve the goals of the ROD. Therefore, at the request of U.S. EPA, an alternate remedy has been developed. The initial submittal describing this alternate remedy was conducted in the August 1998 Conceptual Work Plan (3). Subsequently, based on Agency comments (4,5,6), the Conceptual Work Plan was revised and resubmitted as the February 1999 30% Remedial Design (7). The individual remedial components as contained in the ROD (1992) are collectively referred to as the "ROD Remedy", and the individual components of the alternative remedy presented in the Conceptual Work Plan and 1999 30% Remedial Design are collectively referred to as the "Final Remedy". The ROD was amended in July 1999 to reflect changes of the original ROD Remedy to the Final Remedy.

1.1 SITE LOCATION AND SURROUNDING AREA

The Site is bordered on the east and northeast by Colfax Avenue as shown on the Drawings. An abandoned leg of the Chesapeake and Ohio Railway bisects the Site in a northwest-southeast direction, between the fenced ACS operating facility (north) and the fenced OFCA (south). ACS now owns these tracks and operates them for holding and switching tank cars. The Site is bordered on the south by the Griffith Municipal Landfill (closed) and the abandoned Erie and Lackawanna Railway. On the north, the Site is bordered by the Grand Trunk Railroad and to the west by wetlands areas.

Approximately 33 acres are present within the Site, with the On-Site Area (ACS operating facility) covering 15 acres, and the OFCA and Kapica-Pazmey (K-P) Area (at the southern end of the Site, where a former drum recycler was located) covering 13 acres. The wetlands to the west of the Site make up approximately 5 acres.

1.2 SITE BACKGROUND

The Site began operations in 1955, with reclamation of spent solvent waste. The Site accepted solvent mixtures containing alcohols, ketones, esters, chlorinateds, aromatics, aliphatics, and glycols that contained various residues. Other processes that have operated at the Site since 1955 include specialty chemical manufacturing in small batches, burning of still bottoms and non-reclaimable materials in incinerators (1965-1970), epoxidation and bromination operations, and storage and blending of waste streams for ACS's secondary fuel program.

The approximate area of drum storage was a 250-foot by 450-foot parcel, located in the northern third of the fenced ACS, Inc. facility. The drum storage area was visible in a 1970 aerial photograph. However, an aerial photograph from 1973 indicates that the area was clear with no sign of drums on the ground surface. Approximately 400 drums containing sludge and semi-solids of unknown types were reportedly disposed of inside the plant (this area was named the "On-Site Containment Area" or "ONCA")

From 1988 to 1992, a Remedial Investigation/Feasibility Study (RI/FS) was conducted at the Site. In 1992, a ROD was executed which described the remedial action to be implemented on the site. The remedial action identified in the ROD (ROD Remedy) is discussed in Section 2 of this Plan.

During the RI in the late 1980s, a test pit was excavated in the ONCA, where drums were thought to be buried. Drums were found to be buried on their sides, stacked 3-high and closely packed together. Various liquids were observed in soil surrounding some of the drums, such as brownish water, and an oil-like liquid. In addition, a viscous blue liquid was observed leaking from several drums. The majority of the drums were noted to be dented and corroded, but largely intact. Construction activities conducted during installation of the Perimeter Groundwater Containment System (PGCS) and Barrier Wall Extraction System (BWES) verified the presence of buried drums stacked 3-high in the ONCA. A geophysical investigation was subsequently conducted in February 1998 to determine the extent of the buried drums in the ONCA. Based on past RI results, recent construction activities, and the 1998 geophysical investigation, three areas of buried drums were identified, and are shown on the Drawings.

The Still Bottoms Pond Area (SBPA), located in the central portion of the ACS facility, served as a repository for still bottoms waste from the solvent recycling process. This area contained a pond and "treatment lagoon" where still bottoms were disposed. The pond and lagoon have since been filled in with drum carcasses, rubble, soil, and other debris. During the RI, many borings were advanced in this area, and the concentrations of contaminants in the area indicate that it is a significant source area on Site. Further description of the extent of contamination is included in Section 1.3.

The wetlands to the west of the ACS facility were investigated in 1996 to determine the extent of impact from facility operation on the wetlands. Analytical samples collected during this investigation indicated that certain localized sediments in the wetlands area were contaminated with polychlorinated biphenyls (PCBs). These PCBs likely were transported from the facility via surface water runoff from the facility which drained into the wetlands areas.

The Off-Site Area of the Site is located south of the ACS facility railroad tracks and encompasses the OFCA and the K-P building area. A large portion of the Off-Site Area is essentially a continuation of the Town of Griffith landfill. During the RI, installation of soil borings indicated contaminated areas in the central and southern portions of the Off-Site Area. The barrier wall construction, which included excavation of several hundred feet at the perimeter of the Off-Site Area, verified the landfilled nature of the area. During the Pretreatment Material Handling and LTTT Studies, the central Off-Site Area was found to contain deteriorated drum carcasses and parts. This area is also a significant source area on Site.

In February 1997, as part of the expedited interim remedial measures, a groundwater pumping system was installed in the wetland area. The pumping system referred to as the PGCS, provides containment for a groundwater plume in the northwest portion of the Site. In addition, a groundwater treatment system, including phase separation, UV/oxidation, metals precipitation, filtration, air stripping, and carbon adsorption, was constructed to treat groundwater from the PGCS.

In 1997, a continuous barrier wall was installed around the ONCA, the ACS operating facility, the OFCA, and the K-P Area to contain the contamination source areas. The barrier wall encloses the delineated source areas and buried waste at the Site. A groundwater extraction system inside the barrier wall, comprised of eight 100-foot long extraction trenches, was installed to maintain a hydraulic capture zone within the barrier wall, and is referred to as the BWES. Groundwater from the BWES is also treated in the groundwater treatment system.

The PGCS has been operated since March of 1997, and the BWES was started-up in May 1997. Groundwater from these systems continues to be treated through the groundwater treatment system and discharged to the wetland in accordance with standards established by the U.S.EPA and IDEM. Based on the groundwater treatment plant effluent data and groundwater levels collected from within the barrier wall, these interim systems have successfully, isolated the source areas of the Site thus preventing further off-site groundwater contamination from occurring and providing active treatment of groundwater from within the barrier wall (BWES) and in the north and northwest portion of the Site, outside the barrier wall (PGCS).

1.3 WASTE CHARACTERIZATION

The interim remedial measures cut off the groundwater migration pathways from the source areas and provide mass removal and treatment of contaminated groundwater. However, the soil contamination source areas have been contained but not directly treated to date. Therefore, to fully understand the Final Design, the source areas will be discussed here. The source areas, in general, are those areas that contain "buried waste," defined in the Statement of Work (SOW) section of the ROD as those areas of contamination with VOC concentrations greater than 10,000 mg/kg or PCBs concentrations greater than 10 mg/kg. In addition to the primary source areas, areas of "contaminated soil," defined in the SOW as concentrations in excess of clean-up goals but less than those defined as buried waste, exist near each of the source areas.

It is important to note that the SOW anticipated a remedial action involving LTTT and a residential end-use for determining the risks at the Site. However, based on results from the Pretreatment/Materials Handling and LTTT Treatability Studies and the revised Baseline Risk Assessment, the remedial action will not include LTTT. The risk calculations will be based on an industrial end-use for the Site, as stated by the Agency. Therefore, the clean-up goals will be modified from those listed in the current ROD.

To gain a better understanding of the primary source areas addressed by the Final Design, each of the areas of concern are discussed below.

1.3.1 Source Areas

The primary identified source areas at the Site, presented on the Drawings are:

1. The ONCA. According to the ROD, approximately 400 drums of unknown sludges and semi-solids were suspected to be buried in the ONCA. Subsequent geophysical surveys indicate that the ONCA may contain between 1,000 and 2,500 drums.

2. The SBPA. This area includes the former Still Bottoms Pond, treatment lagoon #1, and adjacent selected contaminated areas of the ACS facility. The SBPA received still bottoms waste from the solvent recovery process. The pond and lagoon were drained and filled with crushed drums containing sludge materials, along with miscellaneous rubble and debris.

3. OFCA and K-P Area. The ROD reported that the OFCA received wastes that included 20,000 to 30,000 punctured, crushed drums, general refuse, on-site incinerator ash, and a tank truck containing solidified residue for disposal. The Pretreatment/Materials Handling and LTTT Treatability Studies, October and

December 1997, respectively indicates that up to 50,000 drums, predominantly crushed and non-intact, could be buried within the OFCA. The area adjacent to the OFCA to the west and south is contiguous with the City of Griffith Landfill and contains landfilled municipal solid wastes. The K-P property has impacted soil from direct disposal as a result of drum washing operations.

Contaminated groundwater has migrated offsite in the upper aquifer. The areas of groundwater impact outside the barrier wall include an area to the north referred to as the North Area and an area to the south/southeast referred to as the South Area. Further discussion of these areas is presented in Section 6.

1.4 CHEMICALS OF CONCERN

The chemicals of concern which impact the groundwater at the Site are VOCs including chlorinated hydrocarbons and benzene, and some semi-volatile organic compounds (SVOCs) (7). Additional information to clarify the physical setting of the Site, including the geology, may be found in the 1991 RI (8). The expedited interim remedial measures implemented in 1996 and 1997 have contained much of the groundwater plume, and have isolated the sources of groundwater contamination from further migration. Chemicals of concern that are present in the soils and waste at the Site are primarily VOCs and PCBs, and these will be addressed in the Final Design described herein.

1.4.1 Organic Compounds

Based on data collected during the RI and subsequent supplemental sampling, the majority of the VOC contamination lies within the ONCA (associated with the drum burial), the SBPA (as a result of the solvent recovery waste disposal), and the OFCA (associated with the punctured drum and municipal solid waste disposal). The K-P Area contains relatively small, discrete areas of VOC contamination greater than 10,000 parts per million (ppm). Contaminants in shallow groundwater within the barrier wall and off-Site to the north and southeast preliminary contain detectable levels of benzene and chloroethene.

The majority of the SVOC contamination lies within the same areas as VOC contamination: the ONCA, the SBPA, and the OFCA. The majority of SVOCs have characteristics that typically make them less mobile or immobile in the subsurface. Therefore, SVOCs which are not within the flow pathways induced by ISVE operation will not likely migrate. SVOCs that do migrate will be removed through the ISVE system (if in vapor form) or the groundwater extraction system (if dissolved in groundwater or in product form). Immobile SVOC contaminants within the contained areas of the Site were not extensively analyzed during ISVE modeling. However, air venting planned during long term system operation will accelerate the natural biodegradation of mobile and non-mobile compounds.

1.4.2 Polychlorinated Biphenyls

The source areas for PCBs are generally limited to the SBPA, the OFCA, and the K-P Area. The areal and vertical extents of PCBs were determined based on the RI soil sample analytical data. The PCBs present in the SBPA are at or near the surface and based on the revised Risk Assessment, pose an unacceptable risk to the future workers at the Site. There were also some detections of PCBs south of the SBPA, but these detections were generally at depths of between 15 and 20 feet. These PCBs do not pose an unacceptable risk because of their burial depth. As mentioned in Section 1.2, PCBs were also detected in the sediments in the wetlands west of the Site, probably due to the historical off-site transport of PCB-laden sediment via storm water runoff from the Site.

PCBs were also detected in the OFCA and K-P Area, although the detections of PCBs in these areas were more random than in the SBPA, as might be expected in a landfilled area. Because of the nature of waste placement in this area, the PCB contamination is likely not contiguous throughout the area.

1.4.3 Inorganics

The primary areas of inorganic contamination on Site contain lead concentrations in excess of 500 ppm and are located in the SBPA, the OFCA, and the K-P Area. Detected lead concentrations in the SBPA were detected in excess of 500 ppm in two test pits and one soil boring. This area lies within the PCB-contaminated area, and will be covered as part of the Final Remedy. Concentrations of lead in excess of 500 ppm were detected between 3 and 10 deep feet in the K-P area and between 10 and 15 feet deep in the OFCA, both of which will be covered as part of the Final Remedy. A single test pit excavated in the ONCA contained lead in excess of 500 ppm. This area is within the area that will be excavated during the ONCA drum removal, and will be placed in the Fire Pond to be covered as part of the final remedy.

1.5 RISK ASSESSMENT

The Revised Baseline Risk Assessment developed for the site by the ACS RD/RA Group was completed in September 1998 (9), and submitted to U.S.EPA for review. The findings of that Risk Assessment were used to define the exposure areas requiring remedial action at the Site, as part of the Final Remedy. U.S. EPA indicated that they are developing a separate Risk Assessment, which has not yet been completed.

2.0 FINAL REMEDY SUMMARY

According to the ROD, under current-use scenarios, the primary risk of exposure from the Site contamination would be through:

1. Incidental ingestion, inhalation of vapors and dermal contact with contaminated groundwater

2. Inhalation of vapors from subsurface releases and fugitive dust from surface contaminants

3. Ingestion and dermal contact of contaminated soil, and

4. Ingestion and dermal contact with contaminated media in the wetlands, surface water and sediment in the site's drainage ditches.

For future-use scenarios, risk from exposure could occur from ingestion, dermal contact and inhalation from the contamination in the groundwater, soil, vapor emissions, and surface water.

The risk scenarios are based on a residential property use at a 10^{-6} Target Cancer Risk and a Hazard Quotient less than 1. Remediation levels were established based on these risks and presented in the SOW. Based on the revised Baseline Risk Assessment (10), the residential use scenario for the Site is not appropriate, because of the history of industrial use, industrial zoning on the property, current uses, and the landfilled nature of the Off-Site Area. Treatment of the contamination at the Site to address a residential risk level would not provide benefits to the community, given that a removal action would have a much greater short-term risk without the long term benefit of significant additional risk reduction. Therefore the original ROD remediation levels and the remedy itself needed to be modified to reflect the industrial use scenario.

2.1 ROD REMEDY

The following major remedial action components were established in the original ROD Remedy:

1. Groundwater pumping and treatment to "dewater the Site" and contain the groundwater plume;

2. Excavation and off-site incineration of the 400 drums in the ONCA;

3. Excavation of buried waste for LTTT;

4. In-situ soil vapor extraction (ISVE) pilot study of buried wastes in the On-site Area;

5. ISVE of contaminated soils;

6. Continued evaluation and monitoring of wetlands, and if necessary, remediation;

7. Long term groundwater monitoring;

8. Fencing the Site;

9. Implementation of deed and access restrictions and deed notices; and

10. Private well sampling with possible well closures or groundwater uses advisories.

Several of these actions have already been completed or implemented at the site:

1. Groundwater pump and treat system
6. Evaluation and monitoring of the wetlands
7. Groundwater monitoring program
8. Fencing the Site
9. Implementing deed and access restrictions and deed notices, and
10. Private well sampling program

In addition, a containment barrier wall was constructed around the Site source areas. The barrier wall contains the Site source areas and the contaminated groundwater beneath the site. One foot of clay cover has also been placed on the Off-Site Area. Other actions will be implemented as part of the Final Remedy:

2. ONCA drum removal and off-site disposal

6. Excavation of PCB-contaminated sediments (>1 ppm) in the wetlands for on-site consolidation (<50 ppm) and off-site disposal at licensed TSCA-approved landfill (>50 ppm)

4., 5. In-situ soil vapor extraction (although Item 4 will be a phased Start-Up of ISVE Systems and not the originally required pilot study)

The need for the alternate to the ROD Remedy is illustrated by the results of the 1997 Pretreatment/Material Handling and LTTT Treatability Studies (1,2), which were conducted to evaluate that thermal technology as a remedy. The results of the studies showed that even though LTTT can be effective at treating organic compounds, implementing the technology at the ACS Site would be impractical based on the following findings:

- A severe explosion hazard would exist from the excavation, handling, and treatment of VOC-contaminated material. This is especially true in the treatment system off-gas unit, where high concentrations of organic vapors could buildup, due to the heating of the soil to be treated. In addition, available unit designs are unable to handle the high vapor concentrations.

- Approximately half of the contaminated material in the OFCA contained municipal waste that was covered or commingled with soil. The amount of municipal waste was estimated to be 30 to 60 percent by weight. Since municipal waste is not amenable to LTTT, it would have to be managed separately, cleaned of the chemicals of concern, and disposed off-site. Steam cleaning, as required by the ROD, is not practical on municipal waste. Therefore, other management options for the waste would have to be investigated.

- Approximately 73 percent of the VOCs were lost as fugitive emissions during sample preparation for the treatability study, which implies that VOCs similarly will be lost as fugitive emissions during full-scale handling and blending operations. This situation would be inconsistent with controlling vapor emissions during excavation and would require an extensive engineered system in an attempt to minimize the short-term risk to the Site workers.

The Thermal Treatability Study (2) concluded that it would be necessary to develop an alternate remedy to manage the organics. Many separate treatment technologies were evaluated in the 1992 Feasibility Study (6) and subsequently screened out based on effectiveness, implementability, cost, or other criteria. The technologies that remained following the screening process are incorporated into the Final Remedy.

Because of the Industrial/Commercial nature of the Site property, a final remedy that consists of removing the principal threat by source reduction, process waste treatment and containment is acceptable under the National Contingency Plan (NCP). Therefore, the following remedy has been developed for the Site.

2.2 FINAL REMEDY

The remedial action objectives established in the ROD for the Site are:

1. Minimize exposure to contaminated soil, groundwater, buried drums/liquid wastes/sludges, or other substances which would result in a risk greater than the acceptable risk range identified in the ROD;

2. Restore groundwater to applicable state and federal requirements;

3. Reduce migration of contaminants off-site through water, soil or, other media; and

4. Reduce the potential for erosion and possible migration of contaminants via Site surface water and sediments.

To achieve these objectives, under the Final Remedy, the items listed in the ROD remedy would be implemented, except for LTTT of the contaminated wastes and soils. The risks posed by the contaminants at the Site will be addressed as follows:

1. Incidental ingestion, inhalation of vapors, and dermal contact with contaminated groundwater will be prevented through containing the groundwater with the existing barrier wall, covering the Site, containment of groundwater plume, enhancement of natural attenuation/biogradation of groundwater contaminants, and groundwater pumping and treatment to remove contaminants.

2. Inhalation of vapors from subsurface releases and fugitive dust from surface contaminants will be prevented by covering the source areas and treating subsurface contaminants with ISVE.

3. Ingestion and dermal contact with contaminated soil will be prevented by covering the Site source areas and limiting Site access.

4. Ingestion and dermal contact with contaminated media in the wetlands, surface water and sediment in the site's drainage ditches will be prevented by covering the on-site source areas and excavating the PCB-contaminated sediments in the wetlands.

The Final Remedy has the following elements: 1) source (mass) reduction, 2) treatment of process wastes, and 3) containment of wastes. These elements will serve to eliminate contaminant migration from source areas and reduce potential human exposure to acceptable levels. The Final Remedy consists of:

- ISVE in the SBPA *(source reduction and prevention of vapor migration)*,

- ISVE in the areas of VOC impact in the OFCA *(source reduction and prevention of vapor migration)*,

- ISVE in the K-P Area *(source reduction and prevention of vapor migration)*,

- Treatment of extracted vapor *(vapor control)*,

- Installation of an engineered cover over the areas containing buried waste *(containment and prevention of direct contact with impacted soil and vapors)*.

In addition, the expedited remedial actions that currently contain the source areas and groundwater, including the PGCS, BWES, and barrier wall, will continue to operate as part of the Final Remedy. The following items will be conducted or continued in accordance with the ROD:

- Removal of the PCB-impacted sediments in the wetlands area by excavating and disposing sediments off-site at a TSCA-approved landfill or consolidating them at locations inside the barrier wall depending on contaminant concentrations, and in accordance with the April 1999 PCB Sediment Excavation and Wetlands Restoration Work Plan,

- Removal and off-site disposal of the intact drums in the ONCA in accordance with the Agency-approved January 1999 Buried Drum Removal Plan,

- Continued groundwater pumping from the PGCS and BWES and treatment through the groundwater treatment plant in accordance with the performance standard verification plan (PSVP) for the groundwater treatment system,

- Active treatment and monitored natural attenuation (MNA) for groundwater outside the barrier wall in North and South/Southeast areas,

- Long term groundwater monitoring, in accordance with the Agency-approved groundwater monitoring program, and

- Private well sampling, in accordance with the Agency-approved groundwater monitoring program.

The remedial components of the Final Remedy are shown on the Drawings. The remainder of this document presents descriptions of the individual components for the Final Remedy.

3.0 IN-SITU SOIL VAPOR EXTRACTION

3.1 DESIGN CRITERIA

In-situ soil vapor extraction (ISVE) is a physical remediation technology designed to remove volatile and semi-volatile compounds from contaminated subsurface media. ISVE uses a vacuum-induced air flow through the subsurface to remove the vapors in the pore space. Initially, mass is removed via advection, in which the accessible mobile vapors present in the pore space of the soil are removed. Once the accessible mobile soil vapors are removed, ISVE is limited by the rate at which VOCs, absorbed on the soil particles, trapped in the pore space as liquid, and dissolved in the pore water, partition (volatilize and diffuse) into the pore space. This is referred to as diffusive flow regime.

The ISVE remediation process will be enhanced by air introduction into the subsurface soils. Previous studies at the Site indicate that biodegradation of existing constituents will occur through air introduction. Air introduction, or venting, through designated ISVE wells will significantly enhance biological activity responsible for aerobic degradation of VOCs and SVOCs. Air venting will also be used to induce specific air-flow paths within each ISVE system, thus limiting short circuiting.

Because the barrier wall already contains the source areas at the Site, the main objective of ISVE at the ACS Site is VOC reduction in these source areas by extracting mobile VOCs, and, to some extent, SVOCs from below the ground surface. Volatile constituents will be removed from preferential air and water flow pathways, where contaminants, if their physical and chemical characteristics are such that they are mobile, will migrate. Subsurface constituents will have varying levels of mobility depending on the specific characteristics of the compounds, existing partitioned phase of the compounds, and local soil properties. Contaminants that are less mobile, such as SVOCs, which are not within the flow pathways induced by ISVE operation will not likely migrate. SVOCs that do migrate will be removed through the ISVE system (if in vapor form) or the groundwater extraction system (if dissolved in groundwater or in product form). Immobile contaminants within the contained areas of the Site are not expected to migrate and will not be recovered by the ISVE system. However, air venting planned during system operation will accelerate the natural biodegradation of mobile and non-mobile organic compounds as confirmed by bench scale pilot studies.

Applying ISVE to the source areas will decrease the mobile contaminants within the barrier wall. This reduction, in conjunction with the barrier wall and groundwater pump and treat system, will further reduce the potential for off-site migration. Mobile-characteristic contaminants, which are not within these preferential flow pathways, will not likely migrate because they are trapped within the soil/debris/drum matrix. If they do migrate, they will migrate to preferential pathways and will be removed through the ISVE system (if in vapor form) or groundwater extraction system (if dissolved in water or in product form). Either way, the mobile contaminants are still within the containment area. Immobile contaminants, including most SVOCs, will experience biodegradation resulting from the air venting of the ISVE systems.

In addition, ISVE will reduce the opportunity for vapor contact through the ground surface by reducing the vapors in the subsurface and minimize the VOC loading in the treatment plant by removing VOCs before they dissolve into the groundwater. This remedial component is consistent with the objectives of the Final Remedy for the ACS Site, as defined in the ROD, to address principle threat by reducing the risk of exposure to contaminated vapors and reducing the potential migration of mobile contaminants to the groundwater.

3.1.1 Areas To Be Treated With ISVE

The areas containing high VOC concentrations are found in four primary areas:

- On-Site Containment Area (ONCA)
- Still Bottoms Pond Area (SBPA)
- Off-Site Containment Area (OFCA)
- Kapica-Pazmey Area (K-P Area)

In the ONCA, the elevated levels of VOCs are coincident with the buried drums. The drums within the ONCA, as defined by the geophysical investigations, will be removed and disposed off Site. Visually impacted soils will also be excavated, placed in the Fire Pond located in the SBPA, covered, and treated by ISVE. A drum removal plan (Montgomery Watson 1999) that discusses the drum removal in greater detail has been prepared and approved by U.S. EPA.

For the other three areas of elevated VOC contamination, the percentage of total VOCs present was estimated using the results of previous soil sampling as follows:

Area	Distribution of Estimated VOC Source within Area	Percentage of Area Soil Mass that is Impacted with VOCs
Still Bottoms Pond	63%	1.6%
Off-Site Containment	31%	1.1%
Kapica-Pazmey	6%	1.3%

3.1.2 Extent of Volatile Organic Soil Contamination

The areal and vertical extent of total VOC contamination was estimated from analytical results of soil samples collected during the RI and subsequent investigations. Boundaries of the VOC contamination were defined by evaluation of the sample concentrations and the sample locations. A concentration of 10,000 ppm was used to define the outer boundaries of buried waste, as defined in the ROD. The majority of the VOC contamination lies within the ONCA (associated with the drum burial), the SBPA (as a result of the solvent recovery waste disposal), and the OFCA (associated with the punctured drum and waste disposal).

The K-P Area contains relatively small, discrete areas of VOC contamination greater than 10,000 ppm.

Once the areal and vertical extents of contamination were estimated, the total VOC mass in each source area was estimated for use in the ISVE models and to determine at what depth a majority of the VOCs are located. The mass in each area was estimated from the average VOC concentration of the soil samples within the boundary of a given area. Details of the calculation were provided in Appendix A of the 30% RD. The actual mass, however, is unknown because the calculation is based on discrete soil boring data and reasonable, although uncertain, assumptions. Review of the soil boring data shows that the soil sample concentrations vary from samples of high concentration to samples of lower concentrations directly adjacent to each other, within the boundary. This variability indicates that there are localized areas of VOCs within areas of relatively unimpacted soil; typical of areas with buried drums, sludges, and debris. Because of the variability, an accurate estimate of mass is not possible.

3.1.3 ISVE Modeling

As outlined in the 30% RD, ISVE Modeling was conducted to: 1) determine if ISVE was a feasible remedy and 2) develop preliminary design criteria. Two screening models, Hyperventilate® (11) and BioSVE®, which are recommended by the U.S. EPA (12), were used. Both models use simple mass transfer and partitioning equations such as the ideal gas law to predict VOC removal at initial startup of the ISVE system, during advective flow. The mass removal during diffusive flow is not predictable from the models, as the VOC removal rate will decrease over time. However, understanding this, the models were used as tools to estimate the feasibility of ISVE for application at a Site. A range of input variables was used to conduct the modeling, so that the modeled output range would give a gross indication of what could be expected from the ISVE Systems. Based on these input variable ranges, the models provided preliminary estimates of mass removal, desired removal rates, achievable flowrates, and other preliminary design parameters.

The model outputs typically represent ideal and initial conditions such as those that could potentially be observed within the first few weeks of start-up. The model output values represent maximum design criteria under ideal conditions therefore, the models were used to only address the feasibility of ISVE as part of the Final Remedy. Under actual operating conditions, especially during steady state removal or the diffusive flow regime, concentrations and flowrates are expected to be significantly reduced. For example, the mass removal rates are expected to decrease within the first several months as the accumulated vapor that is accessible to the vacuum is extracted. Often, ISVE systems are designed based on the model's ideal and start-up conditions, which leads to an over-designed system that allows for no flexibility as vapor concentrations decline. Also, in many cases once the vapor has declined, the operation is assumed to be completed. The system for the ACS Site has been designed to address the decline in vapor rates to prevent an oversized, inflexible system and to provide a logical approach for shut-off criteria to address rebound effects.

3.2 DESIGN CONSIDERATIONS

Preliminary design of the ISVE system included consideration of the challenges previously identified in meetings and conversations with U.S. EPA and IDEM personnel. These challenges included uncertainties regarding effectiveness of ISVE around buried debris and garbage in heterogeneous landfills, free product recovery, and "short circuiting" of air flow. Specific design features related to each of these issues are summarized in the following paragraphs.

3.2.1 ISVE Effectiveness Around Buried Debris and Waste

The subsurface at the Site includes buried debris, municipal waste, and other objects that introduce pockets of air into the subsurface due to imperfect packing of soil. These pockets would represent channels for preferential flow in the subsurface and could potentially dominate the vapor flow pattern induced by the applied vacuum in the ISVE system. For this reason, the ISVE system has not been designed to induce uniform vapor flow through the subsurface, but rather to prioritize recovery of the contaminants in certain areas depending on the potential for those contaminant areas to impact groundwater and soil within the barrier wall in the future. This natural prioritization of contaminant recovery (or preferential recovery) will first remove the contaminants that have the greatest potential for future migration.

Preferential recovery occurs because contaminants are recovered first from the zones of highest vapor flow during ISVE, which is also expected to be the zone of highest contaminant distribution. The concentration of contaminants is likely greatest in the voids caused by heterogeneities, such as collapsed drums and garbage, because these zones offer the least resistance to vapor migration. These are the same zones in which preferential flow will occur during ISVE. Therefore, preferential flow in these zones during ISVE will actually optimize initial recovery of contaminants and will provide early removal of contaminants from these pockets of highest concentration. The ISVE system will include valves on individual vent pipes in the blower shed, and each well head will have a removable well cap, allowing each well to be used either as a vacuum extraction point or as an air vent to influence the pathways as necessary. Also, the system will enhance biodegradation of the volatile and semi-volatile organic contaminants.

3.2.2 Free Phase Product

Free phase product is a priority for removal from the Site because free phase product has the highest potential to impact soil or groundwater in the future. Although small amounts of free phase product have been observed at the Site during previous investigations, there do not appear to be large volumes of free phase product at the Site, and no evidence of pooled Dense Non-Aqueous Phase Liquids (DNAPLS) has been detected. A sheen has been detected in selected wells, suggesting the presence of Light Non-Aqueous Phase Liquids (LNAPLS), but measurable thicknesses of free product have not been detected in any well. The presence of a sheen in selected wells suggests that free product, where present, exists only at low volumes that are immobilized as ganglia or pockets in soil or in the landfilled mass, above the water table. If, after installation of the ISVE wells, recoverable or pumpable free product (either LNAPLs or DNAPLs) is detected in one or more of the wells, passive recovery canisters or total fluid pumps can be easily retrofitted into the well(s) to recover the product for appropriate disposal.

Since free product may exist at low volumes where it is found on Site, and would be non-recoverable through traditional pumping or collection systems, ISVE is an appropriate technology to maximize recovery. ISVE provides recovery of volatilized constituents via a vacuum-induced vapor flow through the vadose zone between the ground surface and water table and through the dewatered zone. ISVE uses the same above ground equipment and recovery mechanisms as bioslurping, which is often mentioned specifically as a free product recovery technology. As ISVE is operated, vapor will preferentially flow through the zones with the greatest proportion of void spaces, which may be caused by debris or garbage. These zones of preferential flow are likely to also be the greatest areas of accumulation of free product since free product will similarly migrate according to lines of least resistance. Therefore, the volatile compounds at the Site are expected to volatilize relatively quickly into the flowing vapor stream and vapor recovery from the ganglia of free product will be optimized.

3.2.3 Smearing

If free phase product is present in the soils floating atop the water table, the potential exists for "smearing" this product across the soil matrix as this water table is lowered. Smearing occurs when a pool of free phase product is mobilized through the soil and leaves residual product in its path. This "smear zone" will greatly increase the surface area of free phase product that will be contacted by vapor recovered via the ISVE system. During vapor extraction, free phase product is recovered by direct diffusion into the vapor. Since diffusion is proportional to the surface area of contact between vapor and the contaminants, increasing the surface area will directly increase the rate of recovery of the contaminants. Therefore, by "smearing" this product, if present, across the soil matrix (thereby increasing the surface area of the contaminants), the effectiveness of the ISVE system on these contaminants will be increased.

3.2.4 Short Circuiting

Short circuiting occurs when a source of atmospheric air is introduced to the subsurface in which the ISVE system is operating and causes this air to be preferentially extracted instead of the contaminated soil vapors. Short circuiting is a concern at any site for which ISVE is considered because short circuiting can cause preferential flow of uncontaminated air through the system, thereby reducing the achievable radius of influence. The most common cause of short circuiting is direct flow of air from above ground into the extraction well because the ground surface is not sealed. This potential for short circuiting will be minimized at the Site because the entire ground surface over the ISVE system will be sealed with an engineered cover as a minimum. The ISVE system, moreover, is designed to address a small amount of short circuiting given that individual wells can be adjusted to reduce or increase flow and vacuum or opened to introduce air into the system at preferential points, thereby redirecting the preferential flow paths that the atmospheric air follows.

3.3 DESIGN

Design and installation of the ISVE system will be implemented in stages. All of the planned wells, and a subset of the full-size ISVE extraction and treatment system will be installed initially in the OFCA and K-P Area and will be operated in lieu of a pilot study. Results from operation of the initial system will provide the basis for implementation of the full-size extraction and treatment system. The initial OFCA and K-P ISVE system will consist of a single blower and off-gas treatment system; all extraction wells and conveyance piping will be installed concurrently with the initial ISVE system. Following that start-up of the OFCA and K-P Area initial ISVE systems, the system will be upgraded as necessary, to operate at full-scale. The SBPA system will be similarly started up in phases.

The major components of the ISVE system will consist of:

- ISVE and Dual Extraction wells and piping
- Air Sparge Points
- Vacuum blower system
- Condensate removal system
- Extracted vapor treatment system

A design memorandum detailing the design of the ISVE systems is contained in Appendix B.

3.3.1 ISVE and Dual Phase Extraction Wells and Piping

The ISVE and dual phase extraction well system consists of extraction wells and buried vapor and groundwater extraction pipes.

The ISVE extraction well design consists of:

- 10 inch boreholes.
- 4-inch stainless steel screens with lengths that are either 5, 10, or 15 feet.
- 4 inch PVC or stainless steel riser pipes depending on contaminant concentrations at well location.
- 5 feet minimum solid casing below the interim (clay) covers.
- Stick-up wells on the OFCA, KPA and most of the SBPA. Only the SBPA wells will have locking protective casings. The top of casing for the stick-up wells will range from 2 to 3 feet above the interim clay cover.
- Flush mounted wells will be installed within traffic areas of the SBPA.
- Wells will terminate near or several feet into the dewatered groundwater levels depending on distribution of contaminants in the area.
- 30 wells in the OFCA.
- 12 wells in the K-P Area.
- 25 wells in the SBPA (a total of 46 wells in the SBPA including the dual phase extraction wells).

The dual phase extraction well design, which will be installed in the SBPA, consists of:

- 12 inch boreholes.
- 6-inch stainless steel screens with lengths that are either 15, 20, or 25 feet.
- 6-inch PVC riser pipes.
- 5 feet minimum solid casing below the interim (clay) covers.
- Flush mounted wells installed in traffic-loaded vaults.
- Well will terminate at or near the subsurface clay till.
- 21 wells in the SBPA (18 @ perimeter, 3 in central portion).

Wells will be installed so that the screened portion of the well is within the estimated vertical distribution of contaminants in the area. The screens will be at least 5 feet below the top of interim cap to avoid short circuiting of atmospheric air through the ground surface.

A well spacing of 60 feet was determined by considering the theoretical radius of influence for wells at the individual areas and the radius of influence reported at other similar sites. The theoretical radius of influence (ROI) for the individual ISVE wells was estimated using the Darcy derived equation developed by P.C. Johnson found in EPA's SVE Handbook (EPA, 1991). This equation uses the hydraulic conductivity to estimate ROI, specific vacuum, and achievable flowrates from an ISVE well. As used in this design, the ROI is defined as the radius of the area around each ISVE well from which vapor could be expected to be extracted. The hydraulic conductivity used for the estimations was estimated based on in-situ slug test performed on undisturbed soil during the RI. The estimated ROI ranged from 40 feet in the SBPA to 75 feet in the Off-Site Area using a range of hydraulic conductivities. The actual ROI is expected to vary greatly, especially given the void spaces present in the debris. At similar sites, radius of influences have been reported to vary from 40 to hundreds of feet. To be conservative, a 30-foot ROI (or 60-foot well spacing) was used for the design. Although the 30-foot ROI is conservative, the design utilized this value to minimize the uncertainty regarding vapor capture in the ISVE well fields. It is likely that 30-foot ROIs will be prevalent in each well field.

The number of wells designated for each source area was based on the areal extent of impacted soil and the coverage of a 30-foot ROI. To provide adequate coverage, the wells were placed so that there is a slight overlap of adjacent ROIs. Within the SBPA, the ISVE well locations may need to be field-adjusted to avoid Site structures and avoid interfering with the ACS facility operations, such as designed traffic patterns or drainage swales.

The well heads will be finished above grade in the OFCA, the K-P, and to the greatest extent possible, in the SBPA. Each well head will have a removable cover and each ISVE vapor conveyance pipe will have a sample port andthrottling valve inside the respective blower shed . This configuration will allow accessibility for vacuum and water level measurements and vapor sample collection, if needed.

For the 21 planned dual phase extraction wells in the SBPA, the wells, wellhead fittings, and piping will be installed in below-grade load-bearing vaults 3 feet wide by 3 feet deep.

Initially only 12 wells will contain a pneumatic pump for total fluid extraction. Future groundwater extraction needs may necessitate installation of more pumps in the remaining 9 wells, at which time the system would be supplemented with the requisite number of pumps. To facilitate this, each well will initially be installed with a pump air supply line, two-inch access hole for water level measurement, a pump air exhaust line, and a pump liquid discharge line, as well as a sample and monitoring port, and SVE lateral conveyance line. Separate header piping will be installed to convey groundwater from the wells to the upgraded groundwater treatment plant.

The interim (clay) cover will be installed prior to trenching for the pipe to provide stability and protection for the pipe. Trenches will be conducted through the interim cap and the pipeline laid mostly on the original ground surface. The conveyance piping plan will involve laying 2 to 3 inch HDPE pipe within the interim (clay) cover to minimize trenching and the associated handling of contaminated materials. Where possible, SVE lateral lines are designed to run uphill towards the ISVE blower buildings, to minimize potential blinding of the pipe by condensate collection.

Individual SVE lateral pipes will be tied into a 6-inch header (manifold) in the blower buildings. The header pipes will have valves to perform fine adjustments of vacuum and flow and ports for flow measurement and sampling capabilities. Prior to the blower, all header pipes will manifold into a common 8-inch header. A flow meter will be installed prior to the blower and the air dilution valve.

3.3.2 Air Sparge System

Air sparging will be used to address areas of deeper VOC contamination below the elevation of the lowered water table. Several deep samples from borings conducted during the RI showed elevated levels of VOCs in the SBPA and the OFCA (Figure 11 of the 30% RD). Direct push sparge points will be advanced near these sample locations to a depth near the top of the subsurface clay. The design of these sparge points was conducted using United States Army Corp. of Engineers (USACE) guidance (13) and Wisconsin Department of Natural Resources (WDNR) guidance (14) and will consist of:

- 1-inch stainless steel screens with 2-foot lengths.
- 1-inch stainless steel riser pipes below the dewatered water level and PVC risers above the dewatered water level.
- Stick-up wells on the OFCA and most of the SBPA. Only the SBPA will have locking protective casings.
- Flush mounted wells will be installed within traffic areas of the SBPA.
- Wells will terminate be at or near the subsurface clay till.
- 6 sparge points in the SBPA and 3 sparge points in the OFCA.

A dedicated compressor will be installed at the blower building of the OFCA and SBPA to provide the necessary pressure and flow for operation of the air sparge points. It is anticipated that the air sparge points will be used following the phased start-up and operation of the ISVE Systems, so that vapor flow in each well field is controlled to the extent possible.

3.3.3 Vacuum Blower System

The ISVE blower system will be housed in two blower sheds located at the OFCA and the SBPA, respectively. The extraction wells located in the K-P Area will be routed to the blower building installed at the OFCA. A 40 horsepower (hp) centrifugal blower will be installed in the OFCA shed as part of the initial system. The blower was sized to deliver 1,000 scfm to the off-gas treatment system at a minimum applied vacuum of 60 inches H_2O at the extraction wells. A dilution valve will be included upstream of the blower to control VOC loading to the off-gas treatment system. A silencer will be installed immediately after the blower for noise and damping control. The blower will be operated with a hand/off/auto (HOA) switch installed in the main control panel, located in the groundwater treatment building, with an emergency shut-off switch installed in the blower shed. Both the hand and auto switch positions will activate the blower; the hand position will override the control system, while the auto position will enable the control system. A pressure switch will be included downstream of the blower to prevent damage in the event of high discharge pressures. When activated, the switch will disable the blower and activate an alarm light in the control panel. A pressure relief valve will also be installed downstream of the blower, to safe guard the system in the event that the pressure switch fails.

The full-size system has been designed to accommodate up to four blowers, two installed at the OFCA and two installed at the SBPA. Selection of additional blowers will be based on data obtained during staged installation and operation of the ISVE system.

3.3.4 Condensate Removal System

During start-up and initial operation of the ISVE system, extracted soil vapor is likely to include entrained groundwater; as the Site is dewatered and much of the subsurface moisture is removed, the quantity of entrained groundwater is expected to decrease. The vacuum applied to the extraction wells will be adjusted to minimize the amount of entrained groundwater while optimizing the vapor flow rate. To minimize blinding of the soil vapor conveyance piping installed in the OFCA and SBPA, entrained water will be removed in the field by sloping the conveyance piping back toward the vapor extraction wells; conveyance piping will not be sloped back toward the extraction wells in the K-P Area because of the existing surface slope. However, the K-P Area ground surface is higher and therefore the vadose zone is much thicker, and groundwater is less likely to be entrained. Entrained water not removed in the field will be removed in a knockout tank installed immediately upstream of the blower. The knockout tank will be fitted with a demister, which will enhance removal of vapor moisture. Liquid collected in the knockout tank will be pumped to the groundwater treatment system for treatment.

A 300-gallon knockout tank will be included with the initial system installed at the OFCA. Collected liquid will be periodically pumped from the knockout tank to the groundwater treatment system influent tank. Because free product may collect in the knockout tank, a low-shear, non-emulsifying pump will be utilized, and stainless steel and high density polyethylene conveyance pipe will be installed above and below ground, respectively. The condensate pump will be operated by an HOA switch installed in the main control panel, located in the groundwater treatment building, with an emergency shut-off switch installed in the blower shed. Both the hand and auto switch positions will activate the pump; the hand position will override the control system, while the auto position will enable the control system. High and low level switches will be installed in the knockout tank to control operation of the condensate pump. When activated, the high level switch will enable the condensate pump, and the low level switch will disable the condensate pump. A high-high level switch in the knockout tank will disable the blower and activate an alarm light in the control panel. A shut-off alarm from the groundwater treatment system will disable the condensate pump.

Future blowers will be installed with dedicated, upstream knockout tanks. The initial 300-gallon knockout tank will function as an equalization tank for the OFCA; future blowers are expected to utilize small, dedicated knockout tanks, which will feed the condensate into the 300-gallon tank for transfer to the groundwater treatment system. A similar configuration will be implemented for the SBPA.

3.4 EXTRACTED VAPOR TREATMENT SYSTEM

Initial mass flowrates of VOCs and SVOCs from the vapor extraction wells are estimated to be greater than the allowable regulatory air emission of VOCs; therefore, it is anticipated that, initially, vapors extracted from the system will require treatment prior to being released to the atmosphere. In consideration of the initial projected concentrations of organics in the extracted vapors, the initial system will include a 1,000 scfm catalytic oxidizer for off-gas treatment, followed by a scrubber to remove hydrochloric acid generated during oxidation of chlorinated compounds in the inlet vapor stream. The off-gas treatment system will be located at the groundwater treatment building while the ISVE blower will be located in a blower shed at the well field.Operation of the blower and off-gas treatment will be interlocked; when the blower is deactivated, the off-gas treatment will be disabled, and when the off-gas treatment is deactivated, the blower will be disabled. The system start-up sequence will be incorporated within the off-gas treatment control logic and will be initiated with a start button on the off-gas treatment control panel. Once the oxidizer has reached the appropriate internal temperature for off-gas treatment, the blower will be enabled. If alarm conditions internal to the off-gas treatment system are activated, they must be cleared in accordance with the off-gas treatment system control logic prior to restarting the system. A manual reset button will be installed in the main control panel, which will clear the overall system alarm conditions; the start-up sequence must then be initiated by the start button on the oxidizer control panel.

A second catalytic oxidizer, which would also be installed at the groundwater treatment building, is anticipated in the future to complete the full-size vapor extraction treatment system. Selection of the second oxidizer will be based on data obtained from operation of the initial system.

A less aggressive vapor treatment system may be used after vapor VOC concentrations decrease below a point at which it is no longer cost effective to treat the extracted vapors with an oxidizer. Depending on the vapor composition, vapor phase carbon may be a viable option. A condenser or chiller/dryer may also be considered in conjunction with the carbon, to reduce carbon usage. Because the Site is located in a non-attainment area and is subject to Indiana and Federal emission standards, air emission control units sufficient to meet these standards will be utilized. At some point, when the vapor concentration and mass discharge drops below the regulatory requirement, direct discharge may be possible. Notification to the State of Indiana will be required to install the air emissions control equipment. The air permit equivalency will specify the applicable regulatory requirements.

3.5 COMPLIANCE AND PERFORMANCE MONITORING

Compliance monitoring will consist of monitoring to comply with air emission regulations; specific sampling requirements are dependent upon air permit equivalency requirements, which will be provided by the Indiana Department of Environmental Management.

Performance monitoring will be conducted to evaluate and optimize the ISVE system. Performance monitoring will include sampling and analyzing the inlet and outlet vapor of the off-gas treatment system, as well as the incoming combined vapor from the well field. Mass removal rates will be calculated and evaluated to assess system performance and mass reduction over time.

Both compliance and performance monitoring will be detailed in the Performance Standard Verification Plan, to be submitted under separate cover.

3.6 PHASED START-UP

ISVE will be implemented first at the OFCA and K-P Areas because the vadose zone is already thick enough at these locations to allow vapor extraction. In other words, additional dewatering is not required in order to lower the water level prior to beginning ISVE operations in the OFCA and K-P Area. However, the groundwater level in the OFCA and K-P Area will eventually be lowered in order to more efficiently ISVE in these areas. After the water level in the OFCA and K-P Areas is lowered to the target level, dewatering of the SBPA will be initiated. The ISVE system cannot be operated at the SBPA until the water level has been lowered approximately 5 feet, because the shallow depth of groundwater in this area would limit vapor recovery by the ISVE system.

Start-up of the ISVE system at the OFCA, K-P, and SBPA will be conducted in phases because of the uncertainties regarding subsurface conditions and the nature of the ISVE mass transfer process. All vapor extraction wells and conveyance piping will be installed through the interim cover as shown on the design drawings. The overall concept of the phased start-up is to initially start operation with a subset of extraction wells, observe performance over an initial period, and use the preliminary results to adjust the design of the full-scale mechanical and vapor treatment system. This will allow flexibility to adjust system operation and provide the basis for system modification to optimize overall operation for the steady state or the diffusive regime. By installing the interim cover first, and then conducting phase start-up of the ISVE system, prior to installing the final covers, changes necessary to the ISVE piping or wells can be accommodated without compromising the final cover on the sites.

The phased start-up will be conducted in lieu of a small-scale pilot study. Because the subsurface conditions of the Site are similar to a heterogeneous landfill, a pilot study would only provide information specific to the limited area influenced by the study. Information obtained from a phased start-up will be more comprehensive than the information provided by a small-scale pilot test because it will be utilizing the full-scale well configuration, will have a longer duration, and will cover a wider area. It will also be more cost-effective because the equipment sizing will be based on long-term operation during diffusive extraction, instead of short-term start-up operation.

Specific features that will be provided by the phased implementation schedule include the following:

- Control of initial operation for uncertain site conditions.
- Capability to change operating configurations to deal with differences in localized conditions.
- Flexibility to modify system configuration and operation as conditions change over time (i.e., from advective to diffusive removal).
- Avoidance of treatment capacity exceedances.
- Optimization of energy efficiency by avoiding oversizing the system to meet initial conditions.
- Reduce cost and minimize pollution by minimizing use of supplemental fuel to maintain contaminant destruction.

Operation of the ISVE system will be conducted in the following seven phases:

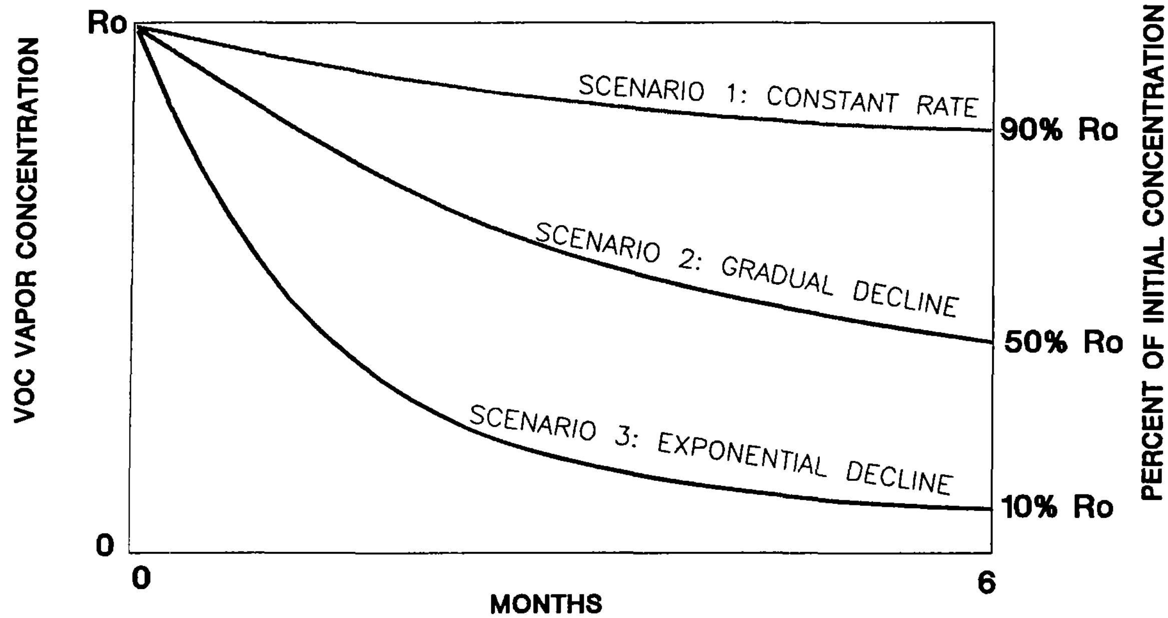
1) **0 to 6 months:** Operation of the initial 1,000 scfm ISVE system at the OFCA/K-P Area.
2) **6 to 12 months:** Evaluation and design of system modifications to optimize operation of the full-size ISVE system to address the entire OFCA/K-P Area.
3) **12 to 18 months:** Installation any system modifications and operation of the full-size ISVE system at the OFCA/K-P Area.
4) **18 to 24 months:** Operation of the initial 1,000 scfm ISVE system at the SBPA.
5) **24 to 30 months:** Evaluation and design of system modifications to optimize operation of the full-size ISVE system at the SBPA (while still operating the OFCA/K-P Area).
6) **30 months to Cycle Phase:** Installation of any modifications and operation of the full-size ISVE system at the SBPA (while still operating the OFCA/K-P ISVE System).
7) **Cycle Phase:** Operation of the ISVE system in on/off cycles, once mass removal becomes limited by constituent diffusion rates.

0 to 6 months: The first phase of ISVE will commence upon construction completion of the ISVE well fields, piping, and 1,000 scfm mechanical system for the ISVE system in the OFCA and K-P Area and will involve applying a vacuum to approximately eight wells in the OFCA/K-P Area. The applied vacuum will be provided by a blower capable of providing up to 1,000 scfm flow at a maximum vacuum of 60 inches H_2O. The actual applied vacuum will be the minimum necessary to effectively influence the farthest wells in the well field, and likely will be less than 60 inches H_2O, to limit preferential flow as much as possible. A 1,000 scfm catalytic oxidizer will be used to provide off-gas treatment.

Because of the expected initial high vapor concentrations, it is likely that early operation will be limited by the destruction capacity of the oxidizer. Therefore, all of the ISVE wells will not be operated simultaneously during the first 6 months of system operation. The wells will be alternated initially to evaluate differences in vapor and humidity characteristics from each well. Once the characteristics are determined, wells with low and high VOC vapor concentrations can be operated simultaneously to prevent exceeding the treatment capacity of the oxidizer, while maximizing its volumetric capacity. The number of wells operating at any one time will be increased as necessary to maintain maximum destruction of hydrocarbons in the oxidizer.

6 to 12 months: During operation of the initial system, VOC concentrations in the extracted soil vapor will decline over time due to the nature of the soil vapor extraction process and the mass transfer phenomenon. The decline may be approximated by one of the three characteristic patterns shown in the figure below.

CHARACTERISTIC PATTERNS OF VAPOR CONCENTRATION DECLINE



Concentrations may decline gradually in a nearly straight line as shown in Scenario 1, moderately as shown in Scenario 2, or exponentially and sharply as shown in Scenario 3. Scenario 1 represents a condition in which the extracted vapor is from a significant source such as a trapped pool of free phase product in void spaces. Scenario 2 represents a typical decline in concentration from a typical ISVE system and site. Scenario 3 represents conditions in which the accessible zones of high concentrations are relatively small and are quickly removed; an asymptotic level would be reached relatively quickly representing the long-term removal rate of VOCs from the subsurface. It's likely that different zones within each ISVE well field will have different characteristic patterns, but the ISVE system will likely follow one of the above scenarios.

Following operation of the initial system, from months 0 to 12, a full-size system will be designed, procured, and installed to address OFCA/K-P or ISVE well field areas. Design of the full-size system will be based on results obtained during operation of the initial system. The full-size system will incorporate the initial system and is expected to include an additional knockout tank, blower, and off-gas treatment system (oxidizer and scrubber). The final design of the full-size system will be dependent upon the overall system characteristic decline in concentrations observed during operation of the initial system.

12 to 18 months: The full-size system will be installed approximately 12 months after start-up and begin operation at the OFCA/K-P Area approximately 15 months after start-up of the initial system. It will include additional equipment that will be operated in conjunction with the initial 1,000 scfm system for approximately 6 months. The initial 1,000 scfm off-gas treatment system from the OFCA may be used to start up the SBPA Initial System. Operation of the additional equipment will continue at the OFCA/K-P Area.

18 to 24 months: Operation of the initial 1,000 scfm off-gas treatment system will begin at the SBPA approximately 18 months after start-up at the OFCA/K-P Area. Installation of the initial ISVE system in the SBPA will be scheduled correspond to this time frame. The precise time of startup of ISVE at the SBPA will depend on the dewatering progress in the area. A knockout tank and blower will be installed in the blower shed located at the SBPA to apply a vacuum to a series of initial ISVE wells. The flows and number of wells will be increased as necessary, similar to the 0-6 month operation in the OFCA/K-P Area ISVE System.

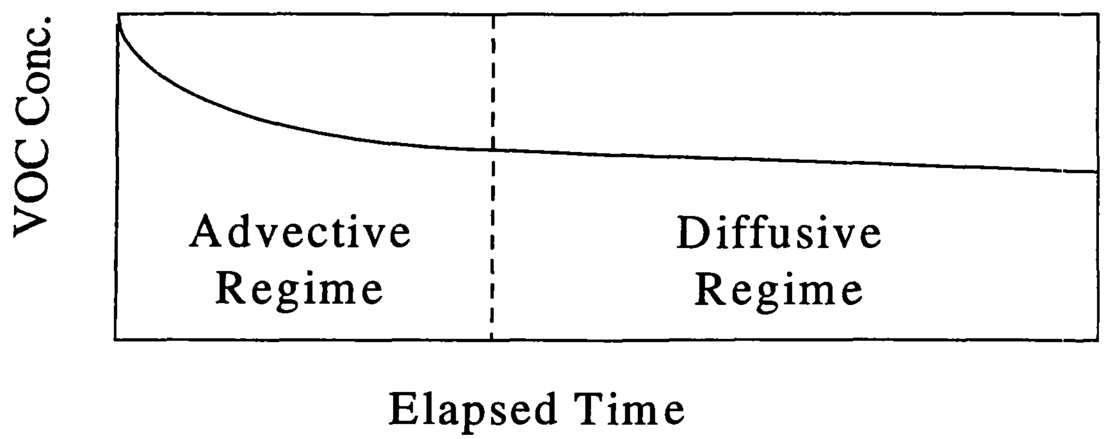
24 to 30 months: Based on results obtained during operation of both the initial system at the SBPA and the full-size system at the OFCA/K-P Area, system modifications will be designed and installed to optimize operation of the full-size system concurrently at both the OFCA/K-P Area and SBPA. System modifications are expected to include an additional knockout tank and blower at the SBPA blower shed.

30 months to Cycle Phase: Concurrent operation of the full-size system at the OFCA/K-P Area and SBPA will continue until mass removal becomes limited by constituent diffusion rates. At that point, the operation at one or all areas will be changed to cycle the system on and off. Long-term system operation is described in more detail below.

Cycle Phase: When mass removal becomes limited by constituent diffusion rates, operation of the ISVE system will be conducted in on/off or "pulsed" cycles. Diffusive Recovery (rather than advective recovery see below) may be indicated in the OFCA or K-P Area before the elapsed 30 months and if so, pulsed operation will be initiated at that time. Long-term system operation is described in more detail below.

3.7 LONG-TERM OPERATION

The ISVE system will be operated until the primary remedial objective is satisfied, which is removal through ISVE and air sparging of the mobile fraction of VOCs from the three source areas with the greatest potential to impact soil and groundwater in the future. The ISVE system will be operated in different modes to maximize efficiency of recovery for the two characteristic contaminant transport regimes. These transport regimes are advective recovery and diffusive recovery. A summary of the transport regimes and graph of characteristic concentrations during each regime is provided in the figure below.



Long-term operation and shutdown criteria have been developed to respond to the physical processes of contaminant recovery that are part of the operation of an ISVE system. The eventual performance of the ISVE system is difficult to predict because of the uncertainty and variability of subsurface conditions. However, the dominant recovery modes, related to the advective transport regime (Stage 1) and the diffusive transport regime (Stage 2), are understood, and shutdown criteria are typically developed to maximize removal efficiencies using these modes.

3.7.1 Stage 1 – Advective Transport Regime

During this regime, the ISVE system will operate continuously and will be optimized to allow full development of the vacuum field across the entire area of concern and to maintain the highest level of vapor removals possible. Development of a vacuum across the specified area will be monitored by evaluating the observed flow patterns. Locations with negligible flow pathways (and therefore negligible mobile contaminants) will be identified by extraction wells with negligible flow, while areas with a high degree of preferential flow pathways (where the majority of mobile contaminants will migrate) will be identified by extraction wells with relatively high flow rates. Short circuiting following initial ISVE operation will be indicated by unexplained increases in vapor flow rate. Potential short circuiting is expected to be limited by covering each area with an engineered barrier.

The constituents removed will include contaminants in the most permeable zones and contaminants that have the greatest potential to migrate from the source area due to their mobility. The advective recovery of contaminants will be characterized by high initial recovery rates, which will decline over time as the most mobile contaminants are recovered and contaminants accessible for advective flow are depleted. While advective transport is significant, the achievable recovery of contamination will be dependent on the total vapor flow rate that can be sustained. Thus, continuously operating the ISVE system to maximize efficiency is critical to optimizing contaminant recovery during the advective regime.

During the advective recovery regime, the ISVE system will be continuously operated until VOC concentrations reach an asymptotic level. As agreed upon in the August 20, 1998 design workshop meeting at the IDEM office in Gary, Indiana, the asymptotic level will be defined as less than a 2.5% change per quarter in the recovered vapor VOC concentration, as determined by three consecutive samples. Once asymptotic conditions are reached, the ISVE system will be operated cyclically, in accordance with the criteria for diffusive recovery. The frequency of samples collected from the vapor stream to define the asymptote will be adjusted (with approval of U.S.EPA) during the diffusive recovery regime based on observed vapor concentrations during system operation as necessary.

3.7.2 Stage 2 – Diffusive Transport Regime

During this stage, vapor concentrations and mass removal are limited by diffusion rates. Diffusive transport will remain relatively constant as ISVE operation continues, because diffusive recovery of contaminants is derived from the slow diffusion of contaminants in vapor from less accessible (lower permeability) areas. The rate of diffusion will be dependent on the concentration gradient between the permeable zones accessed by soil vapor extraction and pockets of contamination in less accessible areas. Therefore, the key to maintaining recovery during the diffusive stage will be to maintain sufficient operation of the ISVE system such that concentrations in the permeable zones (or flow pathway) remain relatively low, providing a concentration gradient between the less accessible areas and more permeable zones. The ISVE system will be operated cyclically during the diffusive stage. The cycle frequency will maintain a concentration gradient while decreasing the total volume of vapor that requires treatment. This operational method will maintain the efficiency of vapor treatment while reducing the time of system operation.

The system will be operated in cycles by alternately operating well sections to allow vapor equilibrium in the soil gas to be achieved at the wells that are shut off. The timing of the ISVE system on/off cycles will be determined by monitoring the concentration in recovered vapor. The purpose of the cycles will be to start the system when vapor concentrations are several orders of magnitude higher than at the time of the last shut-off period. The first off-cycle will last for three months, and then the system will be operated until asymptotic concentrations are again attained, as defined in the previous section. Once asymptotic levels are attained, the system will again be shut down. The duration of each off-cycle will be the same as the previous off-cycle, unless the preceding period of operation was less than half the off-cycle, in which case the off-cycle will be doubled. In summary, each on-cycle will last until asymptotic levels are attained and each off-cycle will last the same or double the previous off-cycle, depending on the length of the preceding on-cycle. The frequency of cycles will be systematically adjusted throughout operation to maximize the efficiency of mass removal.

3.7.3 Stage 3 – Long Term Venting

Either continuous or cycled operation of the ISVE system, as described above, will continue in the OFCA, K-P Area, and SBPA until the total removal rate has been reduced to 100 pounds per day or less for all three ISVE systems as agreed upon during the August 20, 1998 design workshop meeting at the IDEM office in Gary, Indiana. This corresponds roughly with the estimated initial removal rate of the groundwater treatment system. Therefore, the ISVE system will begin long-term venting when its ability to remove contamination is on the same order of magnitude as the groundwater treatment system. Since the groundwater treatment system will continue to be operated to maintain general

Active ISVE end point

water levels within the barrier wall, the active collection and treatment of vapor through the ISVE system will be stopped.

Following active ISVE system operation, groundwater will be allowed to naturally recharge to the barrier wall maintenance level. The ISVE extraction wells will be opened and allowed to vent to atmosphere, and the ISVE wells will function as long-term air vents system. This long-term venting system will allow and maintain a level of biological degradation in the subsurface that will continue to reduce the non-mobile contaminants within the containment system. While long term air venting is implemented, groundwater will be pumped to the groundwater treatment plant at a pumping rate sufficient to maintain a level that will not allow groundwater to overflow the barrier wall or to maintain an inward gradient where possible. This groundwater level will be the maintenance level.

4.0 GROUNDWATER EXTRACTION SYSTEM

A component of the Final Remedy defined in the ROD, is containment of the groundwater plume and collection of groundwater to the north of the Site for treatment. The existing barrier wall provides containment for the plume near the source areas, and the existing BWES removes the contained groundwater to maintain water levels within the barrier wall. The PGCS collects groundwater flowing to the north of the Site for treatment at the GWTP. The BWES and PGCS comprise the Site's groundwater extraction system.

To increase the effectiveness of the ISVE systems that will be installed at the Site, groundwater levels within the barrier wall will be lowered to expose the majority of the soil contamination below the current water table. Once the zone of contamination is exposed, the ISVE systems will withdraw contaminated vapors from the subsurface for treatment. Exposing the soil to air flow will increase the effectiveness of ISVE in the SBPA, the OFCA, and the K-P Area. Therefore, a critical component of the Final Remedy will be lowering the current water table during ISVE operation.

4.1 DESIGN OBJECTIVES

The objectives of the groundwater extraction system inside the barrier wall is to:

- Lower the water table in the OFCA from the current groundwater level of approximately 634 feet amsl to 626 feet amsl. This results in a drawdown of groundwater in the OFCA of approximately 8 feet.

- Lower the water table in the SBPA from the current groundwater level of approximately 634 feet amsl to 629 feet amsl. This results in a drawdown of groundwater in the SBPA of approximately 5 feet..

- Upon completion of the ISVE operations, maintain groundwater levels inside the barrier wall at a target elevation of 631 feet amsl to prevent over-topping and induce an inward gradient, where possible.

Additional information, including historic groundwater levels inside and outside of the barrier wall and expected future hydraulic gradients along the barrier wall, is included in Appendix C.

In addition, the groundwater extraction system and treatment plant must also allow for continued operation of the PGCS and flexibility of routing the influent sources to either the pretreatment or main treatment systems depending upon contaminant levels and flow rates.

4.2 PERFORMANCE REQUIREMENTS

The performance requirements necessary to effectively achieve the design objectives for the groundwater extraction system upgrades were evaluated and are discussed below.

Groundwater extraction rates necessary to achieve each design objective were estimated from the projected infiltration rates, the volume of groundwater currently within the barrier wall that will require extraction, the hydraulic and contaminant treatment capacity of the GWTP, and the implementation schedule for the Final Remedy. The groundwater collection quantities and schedule were initially presented in the 30% RD and are included in Appendix C. Based on these evaluations, the following performance requirements are necessary to effectively accomplish the dewatering objectives:

- The sustainable groundwater extraction capacity of each of the existing extraction trenches in the Off-Site Area (EW-11, EW-12, EW-13, EW-15, and EW-16) is approximately 2 gpm based on pumping data observed during the past 2 years of operation for the 100-ft trenches. The five existing trenches yield an observed combined capacity of 10 gpm. Based on the estimated extraction requirements for the Off-Site Area (Appendix C), a flow of 20 gpm is required to adequately dewater the area for efficient ISVE operation. Therefore, to accomplish the performance requirements, groundwater extraction capacity in the Off-Site Area will be increased by 10 gpm for a total extraction capacity of 20 gpm in the area. By installing an additional 500 lineal feet of extraction trench, this additional 10 gpm can be accomplished.

- The observed sustainable groundwater extraction capacity of the existing 100-ft extraction trenches in the On-Site Area is similar to the extraction capacity of the trenches in the Off-Site Area. Extraction trenches EW-10, EW-17, and EW-18 yield a sustainable combined pumping rate of 6 gpm. The initial dewatering plan for the On-Site Area, as presented in the 30% RD, required dewatering of the entire On-Site Area to obtain the lowered groundwater level. To accomplish this objective the groundwater extraction capacity in the On-Site Area would need to be increased by 27 gpm for a total extraction capacity of 33 gpm. To decrease the required extraction rate while still effectively lowering the groundwater level in the SBPA, localized dewatering of the SBPA was implemented. Using localized dewatering, it is estimated that approximately half of the originally estimated 33 gpm will be required to effectively lower the water table for ISVE. Therefore, only 17 gpm will be required, which will be provided by 21 new dual phase extraction wells in addition to the existing extraction trenches.

- Based on the Final Remedy implementation schedule, the Off-Site Area and On-Site Area will need to be dewatered independently. To accomplish this objective, a separation barrier wall constructed of bentonite slurry will be installed between the On-Site and Off-Site Areas.

- Existing and new extraction wells will be grouped as shown in Table 1 to allow collected groundwater to be routed to the appropriate components of the GWTP based on flow rate and contaminant levels.

- Independent adjustment and monitoring of groundwater pumping rates must be possible from each extraction point.

- Construction should allow for continued use of extraction trenches if damage or blockage has occurred within the filter pack, as may be the case in existing extraction trench EW-13.

4.3 GROUNDWATER EXTRACTION SYSTEM DESIGN

4.3.1 New Extraction Trenches and Wells

Historic operating conditions of the existing groundwater extraction system indicate that a pumping rate of 2 gpm per 100-ft trench section can be sustained. To increase the groundwater extraction capacity in the Off-Site Area by the 10 gpm required for dewatering, 500 feet of additional extraction trenches will be installed. The additional 500-ft of trenching will be obtained by installing a 350-ft extraction trench between the separation barrier wall and OFCA ISVE well field and a 150-ft extraction trench just south of the existing extraction trench EW-15. These locations were selected because historic boring logs indicate that these areas have the least potential to encounter buried refuse during construction.

Installation of groundwater extraction wells as part of the SBPA ISVE system was selected to promote a localized groundwater surface depression in the SBPA. The localized groundwater depression will decrease the required groundwater pumping rate and allow for operation of the SBPA ISVE system. Installation of vertical wells in the SBPA was selected over horizontal collection trenches to decrease contact with subsurface contamination and the potential for encountering subsurface structures that could impede construction. To accomplish localized dewatering in the SBPA, 21 of the ISVE wells will be installed as dual phase extraction wells for collection of groundwater. Based on previous pump testing at the Site (A pumping test was conducted on March 20 and 21, 1995 in accordance with PGCS RD/RA Work Plan to evaluate the hydraulic characteristic of the unconfined aquifer.), the dual phase extraction wells can yield a sustainable flowrate of 1/2 gpm per well for a combined extraction rate of 10.5 gpm. Twelve of the dual phase extraction wells will initially be used for groundwater collection. This number will be increased, as needed, based on dewatering progress.

The new extraction trench and well locations are shown on the Drawings.

The new well pumps will be submersible pneumatic pumps similar to the existing pumps at the Site. Separate piping systems will be used in the SBPA for water vapor collection as detailed in the design of the ISVE systems.

4.3.2 Collected Groundwater Conveyance and Header System

The existing and new extraction trenches and wells will be grouped as shown in Table 1. The grouping will allow the collected groundwater from each collection point to be routed by a header system to either the pretreatment or main treatment systems of the GWTP, depending on flow rates and contaminant levels.

4.3.3 Groundwater Collection Flowrate Control

All extraction trenches and wells will be equipped with an air regulator/filter and ball valve on each airline so that pumping rates of each pump can be regulated independently. The groundwater conveyance pipe from each extraction point will be equipped with a totalizing flow meter and sample port to monitor and sample groundwater pumping from each well as necessary to optimize influent scenarios to the GWTP. New extraction points will be installed with this equipment and the existing trenches will also be upgraded with it.

4.3.4 Collection Trench Filter Pack

Historical soil borings and grain size analyses were used to develop a filter pack for the new extraction trenches and wells. A medium sand with 90% passing the No. 8 sieve and no more than 10% passing the No. 50 sieve will be used as filter pack at the Site.

To minimize transport of fines into and through the collection pipes, the newly installed trenches and wells will be wrapped in a continuous, filament, non-woven polypropylene geotextile with a minimum thickness of 80 mils. The material will have a minimum water flow rate of 139 gpm/ft^2 and a minimum apparent opening size of 0.250 mm.

4.3.5 Additional In-Line Wells

In-line wells will be installed along the new extraction trenches (EW-19 and EW-20) and existing EW-13. Each in-line well will be alternative extraction points along extraction trenches in which a pneumatic pump can be placed to extract groundwater from the trenches' filter pack. These wells will be spaced approximately 100 feet apart along each trench and screened in the trench filter pack material. The in-line wells will consist of a slotted screen riser pipe and control vault. Air supply lines and groundwater conveyance pipes will be ran to each in-line well vault so that each in-line well will be capable of operating a pump if needed. In-line wells will be identified by adding identification letters to the main extraction well identification at each trench. (Example: In-line wells at extraction trench 20 will be identified as EW-20A, EW-20B, etc.) The in-line well for extraction trench 13 will be installed as an operational well to replace existing EW-13.

4.3.6 Piping Runs and Locations

Using flows as listed in Appendix C, head losses were calculated (15) and conveyance piping was sized. Groundwater conveyance piping will consist 2-inch diameter or 3-inch diameter (depending on individual well or series of well flow capacities) high density polyethylene (HDPE) piping. Air supply lines will consist of 1-inch diameter HPDE piping. Piping runs and locations for the groundwater extraction system along with other subsurface conveyance systems for the Final Remedy are shown on the Drawings.

5.0 COVER AND COVER DESIGN

The Final Remedy includes covering the areas of the Site that contains buried waste, as defined in the SOW. The SBPA, OFCA, the area contiguous to the City of Griffith landfill, and the K-P Area will be covered. These areas contain concentrations of VOCs and PCBs high enough to be defined as buried waste in accordance with the ROD. In addition, the K-P section of the Off-Site Area contains elevated concentrations of lead in the soil, which also requires a cover. The main objectives of covering these areas are:

1. Eliminate potential direct contact with VOC- and PCB-contaminated soils (and lead-contaminated soils in the K-P Area);

2. Eliminate potential worker contact with VOC-contaminated groundwater;

3. Reduce the potential for contaminant migration to groundwater by reducing infiltration into these areas; and

4. Provide a surface seal for the ISVE system to minimize potential short-circuiting and maximize the capture of VOC vapors.

In addition, covering these areas will reduce the storm water infiltration into the area inside the barrier wall, thereby reducing the amount of groundwater to be treated by the groundwater treatment plant during ISVE implementation and long-term operation of the BWES.

5.1 COVER REQUIREMENTS

Because covering was not a part of the original ROD, the requirements for covering the ACS Site are not outlined in the SOW. Therefore, several regulatory references were used in the evaluation of various alternatives as provided in the February 1999 30% Remedial Design Report (7). An evaluation of conventional and final designs was conducted to determine an appropriate covering remedy design. Both Federal (U.S. EPA Subtitle D, 40 CFR 264) and Indiana Department of Environmental Management (IDEM - Municipal and Hazardous Waste Landfills, 329 IAC 10-22-7) (16) regulations were used to provide potential design criteria for the evaluation. These regulations are particular to solid and hazardous waste landfills, and therefore are not applicable to the ACS Site. However, they provide useful guidance for design details of covers. IDEM was contacted directly to discuss the relevant and appropriate requirements. IDEM recommended 329 IAC 10-22-7 and deferred to U.S. EPA Subtitle D requirements as guidance (17) for the cover design.

5.2 GENERAL DESIGN DESCRIPTION

5.2.1 SBPA and OFCA Engineered Covers

Delineation of the SBPA engineered cover was established using detected total VOC concentrations exceeding 10,000 ppm and total PCB concentrations exceeding 10 ppm from specific soil sampling locations. Based on the analytical findings, the SBPA engineered cover surface surrounds both the Stills Bottom Pond and Fire Pond and is approximately three acres within the operating portion of the Site. The aforementioned criteria was also employed to delineate the extent of the OFCA engineered cover; however additional criteria included the lead-impacted soils of the K-P Area and the lateral extent of the City of Griffith landfill extending on to the ACS property. Therefore, the extent of the engineered cover on the OFCA and K-P Areas encompasses the areas of buried waste, lead impacted soils, and municipal refuse in the Off-Site Area.

5.2.2 Backfilling

Before construction of the SBPA engineered cover, the Fire Pond will be backfilled with granular soils from the ONCA drum removal excavation and soils and gravel from the SBPA during cover grading activities. As a contingency, excavated PCB-impacted soils from the wetlands area west of the facility may be used to complete the backfill. Since the shallow aquifer intersects the bottom two-to-four-feet of the Fire Pond, a granular soil layer is ideal backfill material for the Fire Pond. Volume estimates of the amount of soil required to backfill the Fire Pond were conducted and further discussed later in this section.

5.2.3 General Grading Under Engineered Covers

Existing soils will be graded to promote surface water drainage prior to construction of both the SBPA and OFCA engineered covers. In addition, the areas surrounding the OFCA and SBPA engineered covers will be regraded, where necessary, to improve storm water run-off and reduce storm water run-on. Subsurface grading plans were developed for each area and are shown on the Drawings. Swales were incorporated into the subsurface grading plan at specified locations to direct sheet flow towards designated discharge points and to avoid facility buildings. Grading of the subsurface for the engineered covers and surrounding areas will primarily conform to the contours shown on the drawings, and shall promote positive drainage.

5.2.4 Interim OFCA and SBPA Engineered Covers

As part of the remedial design, interim-engineered covers were designed for both the SBPA and OFCA to allow placement and installation of the ISVE conveyance pipe, gas extraction wells, and dual extraction wells. During the construction and start-up phases, the OFCA interim-engineered cover will consist of a 12-inch thick compacted clay soil layer installed in six-inch lifts. The 12 inches of compacted clay soil will also serve as a temporary cover, and will allow adjustments to be made, if necessary, in the ISVE systems (piping modifications, repairs, valve or port additions, etc.) during initial start-up of the ISVE systems. In this manner, damage to the final cover due to these potential adjustments will be avoided. Erosion control matting will be placed in areas susceptible to erosion due to steep slopes or high flow concentrations. Following initial ISVE system start-up, the final cover will be constructed atop the initial 12-inch clay soil layer, taking care to incorporate the ISVE wells into the final cover surface. Because the OFCA currently has some compacted clayey soil in place, the placement of the first layer of the cover will be relatively simple, and will consist of supplementing the clay layer, regrading and recompaction. Temporary access roads will be constructed to allow access to remote locations such as the OFCA ISVE blower building and well field. The temporary access roads are designed to consist of a geotextile fabric with an eight-inch gravel subbase.

In the SBPA, the existing gravel/slag surface will be excavated approximately 22-inches below grade along the SBPA engineered cover perimeter. The interim SBPA engineered cover will consist of a 12-inch thick layer of compacted clay soil, covered by a geotextile fabric with six to eight inches of compacted gravel. The geotextile fabric and gravel base course will be placed over the clay soil after installation of the ISVE conveyance pipe and gas and dual extraction wells (which will be installed into the clay layer). The base course will consist of six-inches of nominal ¾-inch diameter compacted gravel aggregate with fines installed above a 16-ounce geotextile fabric. Temporary roads will be constructed to minimize disruption to the ACS operating areas, and allow access to operational areas within the ACS facility. The temporary access roads will be designed to consist of a geotextile fabric with 12-inch gravel layer. It is anticipated that the temporary access roads will exist for approximately 12 to 18 months, and will be subsequently incorporated into the final cover, as part of the final phase of the remedial action, as shown on the Drawings.

5.2.5 Tie-In

Along the SBPA engineered cover perimeter, a vertical cut of approximately 22-inches will be excavated prior to the construction of the SBPA engineered cover. The proposed cut will extend inward at a varying lateral distance around the perimeter and will gradually taper off to the existing ground surface elevation (See Drawings). Following the subgrade grading, uniform layers of compacted clay soil and gravel will be placed over the newly established grade. To prevent water settlement (ponding) along the cover boundary during interim operations, additional clay soil will extend to the delineated perimeter and allow surface water drainage off the interim cover. After the interim period:

- The additional clay soils at the cover perimeter will be removed;
- A geotextile and a lower component of six inches of compacted gravel will replace the perimeter clay soils; and
- The cover will be finished a surface component of four inches of low permeability, high strength asphalt.

Details of this proposed cut and fill tie-in transition are provided in the Drawings.

In the OFCA, the 12-inch compacted clay soil layer will extend over the existing barrier wall along the southern and western edges and blend into the surrounding cover area to the north and east during the interim period. The placement of the 60-mil flexible membrane liner (FML) during construction of the final cover will involve a typical anchor system that extends approximately one foot beyond the engineered cover northern and eastern edges.

Along the southern and western edges of the engineered cap, the FML will extend over the barrier wall a minimum of 18 inches and will be anchored by 24 inches of soil. Details of the OFCA interim and final tie-in transition are provided in the Drawings.

5.3 FINAL COVER REMEDY

5.3.1 SBPA Asphalt Engineered Cover

Construction of the final SBPA asphalt engineered cover will include an alternative high-strength, low permeability asphalt cover mixture, which will provide the necessary low-permeability layer while still allowing for the operation of the ACS facility including loaded semi-tractor trailer access, parking, and other non-intrusive activities.

The final asphalt engineered cover design will consist of the following, from bottom to top:

- A uniform layer of compacted clay soil will be placed over the graded subsurface. This low permeable layer will be 12-inches thick, and installed in six-inch lifts, and will provide interim cover for the area to limit infiltration and provide a surface seal for the ISVE system.

- A 16-ounce non-woven polypropylene geotextile separation layer will be placed between the compacted clay soil layer and the gravel base course layer.

- A six to eight-inch thick compacted gravel base course layer that will provide temporary vehicular and pedestrian access and water drainage and will serve as a subbase for the asphalt. The main access roads will require a 12-inch base course layer.

- A four inch thick (combined) modified asphalt binder and modified asphalt surface course of specially prepared high-strength, low permeability asphalt.

A cross section of the asphalt cover is detailed on the Drawings. Details regarding these three layers are further discussed in the following sections.

5.3.1.1 Asphalt Binder and Surface Course

The four-inch (combined) impermeable modified asphalt binder and surface course will be installed over the prepared gravel base course. The modified asphalt binder and surface course will be constructed to the approximate lines and grades shown on the Drawings. The asphalt binder will consist of a specially produced high-strength, low permeability asphalt. This type of asphalt was developed to be more durable and much less permeable ($<1 \times 10^{-7}$ cm/sec) than regular asphalt.

This type of asphalt mixture has four advantages over traditional asphalt. First, it is blended and installed at higher temperatures than traditional asphalt and typically contain fewer leachable volatile organic compounds than traditional asphalt. Second, it is manufactured with asphalt cement using modifiers that have a molecular weight in excess of 80 times asphalt cement molecules, yielding longer-chained and heavier molecules than traditional asphalt cement. This results in a product with a higher intermolecular stability and a decreased reactivity and solubility. Third, these modifiers do not contain heavy metals or other hazardous material. Fourth, these special mixtures have a lower permeability than traditional asphalt and their permeability characteristics perform similarly to a highly compacted lean clay cap (<1 x 10^{-7} cm/sec). U.S. EPA Region V has recently approved and installed this type of asphalt cover for use at the following CERCLA sites.

- Hill Air Force Base, Utah
- G&H Landfill, Michigan
- Tri-County Landfill, Elgin, Illinois

5.3.1.2 Asphalt Thickness Design

An evaluation was conducted to determine the appropriate asphalt thickness using technical information from the Asphalt Institute (18). The subgrade resilient modulus was calculated using the equation provided with the California Bearing Ratio (CBR) value of 10. This value is considered conservative for typical design values of subbase soils classified as clay, since the provided technical input data indicates that a value of 15 or lower is acceptable. The equivalent axle load (EAL) was determined from parameters such as vehicle type, truck factor, numbers of vehicles driven on the asphalt cover per year, and an annual growth factor of two percent. These factors were used to calculate an overall EAL value that was found to be approximately 1.8×10^5 while a subgrade resilient modulus value was calculated to be 15,000 pounds per square inch.

Using the Asphalt Institute's Design Chart A-23 for "Untreated Aggregate Base 6.0 inch Thickness" in the Thickness Design Manual (18) yielded a minimum required asphalt thickness of 4 inches. It should be noted that the SBPA access roads will have an additional 6 inches of compacted gravel subbase, to account for the heavy traffic loads on these roads.

5.3.2 OFCA Engineered Cover

A very flexible polyethlyene (VFPE) FML will be placed over the lateral extent of the OFCA engineered cover. The thickness of the FML will be 60-mil, selected primarily because of its flexibility and low permeability (4.0 x 10^{-13} cm/s as listed in manufacturer's literature). The flexible FML is also less susceptible to tear if soil settlement occurs, and the 60-mil thickness is more practical for welding purposes. In addition, the selection of the FML limits vertical expansion. The upper component will consist of a 12-inch layer of earthen soil. The earthen material will be used as a root zone to support a healthy root matrix for the overlying vegetative layer. The top layer of the upper component will be a six-inch layer of topsoil that will be planted with a shallow-rooted blend of native vegetation.

5.3.3 HELP Model

The acceptable final cover designs for both areas were evaluated using the Hydrologic Evaluation of Landfill Performance (HELP4) Model (19). The model is a two-dimensional iterative hydrological model of water movement across, into, through, and out of impacted soils. Model simulation results indicate that selected final engineered and surrounding covers significantly reduce the water infiltration.

Weather data utilized for the evaluation were generated by the HELP model as default values for Chicago, Illinois, and were constant for all modeled alternatives. Variables for the modeling input included cover design layer-characteristics such as soil and geosynthetic layer types and thickness. Table 2 summarizes the modeled output results from selected cover and cover final design scenarios. Appendix D contains the complete model input and output.

5.4 SURFACE DRAINAGE SYSTEM

The drainage system for the Site has been sized based on a 100-year, 24-hour storm event for Griffith, Indiana. The surface drainage system will include channels and swales that will be lined with appropriate erosion control measures, such as straw matting, silt fencing, hay bales, and riprap, where necessary. The areas that currently pond water on the ACS facility will be regraded to drain into the existing storm sewer system, or off-site to the north or west wetlands. The drainage patterns for both the SBPA and the OFCA, are shown on the Drawings.

The following are established design criteria, based on sound engineering practices and experience, for the drainage design at the Site.

- Eliminate ponding in areas inside the barrier wall, both on the engineered covers and immediately surrounding the cover.
- Minimize erosion of Site soils.
- Channelize drainage, where possible.
- Provide adequate erosion protection in cover and surrounding channels.
- Drain runoff from covered area as quickly as practical.
- Control runoff from Site.
- Control velocity of stormwater runoff, so that erosion is minimized.
- Provide silt/sediment checks to minimize off-site sediment transport.

5.4.1 SBPA

As mentioned above, the SBPA surface drainage system will consist of constructed swales that will control sheet flow, velocities and sediment transport associated with stormwater runoff from the Site. The swales will guide sheet flow away from facility operating areas and/or along facility buildings to existing catch basins surrounding the SBPA. This part of the surface drainage system design will also prevent surface water from pooling on the engineered cover. Catch basins adjacent to the cover boundary will be raised or lowered, as necessary, to appropriate final ground surface elevations to collect surface water drainage. The collected stormwater will be conveyed via gravity from the existing stormwater collection system and discharged into the wetlands located to the west of the facility.

5.4.2 OFCA

The OFCA surface drainage system design will utilize existing topographic features that will be graded, as necessary, to allow sheet flow to drain off the engineered cover and into engineered channels or swales (See Drawings). Trapezoidal-shaped channels were designed to run along the west property line, immediately east of the designed OFCA engineered cover, and south of the railroad tracks.

5.4.2.1 Channels

The OFCA engineered cover will contain three main trapezoidal-shaped channels that will receive sheet flow from the cover areas. The basis of the channel design is to drain stormwater off the OFCA engineered cover in an efficient, controlled manner. Sheet flow collected by the channels will be discharged into the existing drainage ditch located west of the facility. To minimize erosion, all water conveying channels have been designed with either erosion control matting, where the velocities are low enough, or riprap, where necessary to armor the channel against excessive erosion. The channel locations are provided in the Drawings. An evaluation of various channel designs was conducted using standard open channel flow calculations and the TR-55 method of calculating storm water runoff from the cover. Results of this evaluation are summarized in tables and graphs and are provided in Appendix E.

5.4.2.2 Erosion Control Measures

Erosion control matting (straw matting with fibrous reinforcing) will be placed in most of the OFCA water conveying channels to control erosion from these areas prior to establishment of vegetation. This erosion control matting will eventually bio/photo degrade (degradation usually takes approximately 18 to 24 months), leaving the healthy, established vegetation in place. Riprap has been specified in some channels to provide armor against velocities that induce excessive erosion.

5.4.2.3 Vegetative Layer

A vegetative layer will be established within the topsoil layer following construction in the OFCA. The vegetation will be placed by either hydroseeding or conventional techniques. The vegetative layer at the Site will consist of a shallow-rooted (12 inches or less to prevent root damage to the cover) blend of grasses. This vegetation will protect surface soils from erosion and provide a healthy vegetal cover to promote evapotranspiration. Prairie grasses were considered, but due to the deep-rooting nature of these grasses and potential burning requirement to maintain these grasses, they were not selected for use at the Site.

5.4.3 TR-55 Model

The Technical Release-55 Model (20) was used to determine peak flow discharge for the watershed areas of the OFCA and SBPA. A 100-year 24-hour rainfall distribution was selected because it adequately represents the regional rainfall time distribution and contains the intensity of rainfall for this event. Critical parameters of the model include time of concentration and travel time which represent the amount of time for runoff to travel from the hydraulically most distant point of the watershed and the time it takes water to travel from one location to another in the watershed, respectively. Additional characteristics that influence the model outcome results are the Manning's coefficient, slope, length, and surface area. The SBPA was modeled as one continual drainage area, whereas the OFCA was divided into three discrete discharge areas. A stormwater hydrograph was plotted by the model to determine the peak flow from each drainage area. These hydrographs were then combined where they flowed into similar channels, and/or routed where they flowed into and through a channel reach. The computer model output and a summary table of the peak flows are provided in Appendix E.

5.4.4 Channel Design

A channel design model (21) was employed to design adequate perimeter channels for the OFCA. Using the peak flow discharge rates calculated from the TR-55 Model, the discharge area in conjunction with selected channel depths and varying Manning's coefficients yielded curve plot comparisons for trapezoidal-shape channels. The performance curves were used as a tool to determine an acceptable discharge channel dimension based on flow carrying capabilities. The varying Manning's coefficient was necessary due to variability and uncertainty of vegetative or rock being placed in the channels.

5.5 REMEDIAL DESIGN CALCULATIONS

Preliminary remedial design calculations were conducted for various components of the final cover design including:

- Estimated volumes of soil cut and fill for the engineered and surrounding covers total estimated area;
- Backfill volume of the Fire Pond;
- Quantity and volume of engineered and surrounding cover materials;
- Selection of engineered and surrounding cover materials; and
- Stormwater runoff and sizing of drainage system.

5.5.1 Engineered Cover Volumes/Areas

Volumes of the proposed surface cut and fill were produced using design software in conjunction with a standard CADD package. These estimations involved using a newly developed surface topographic base map of the entire Site. An Indiana-registered land surveyor verified survey field data. Calculations involving the soil quantities for both areas are in-place bank cubic yards. No swell or shrink factors have been applied.

It is estimated that approximately 4,000 cy will be required to bring the Fire Pond up to preliminary subsurface grade. Approximately 6,000 cy of material is necessary to bring the Site up to subsurface grades. All backfill material will come from soil excavated from the ONCA drum removal and proposed onsite cut (grading areas shown on the Drawings). As a contingency, excavated PCB-impacted soils from the wetlands area west of the facility may be used to complete the backfill. These volumes are estimates only and are subject to change. Excavating and grading during Site preparation and other construction activities which may alter the existing surface of the Site, or differences between estimated and actual depths of the Fire Pond will have an effect on the estimated quantities. However, the volumes should be relatively close to actual construction quantities, if there are no significant differences between field conditions and estimated design conditions (grades, slopes, etc.).

Volume estimations indicate that approximately 6,400 cy of spoils are located in the OFCA. This estimate is based on recent survey data used in conjunction with standard design software, and was verified with hand calculations. The spoils will be distributed in key locations of the OFCA to help promote positive surface water drainage. A standard CADD package was also used to estimate the approximate cross-sectional areas of the SBPA and OFCA engineered covers. The total estimated engineered cover areas are approximately 2.9 and 6.4 acres, respectively.

5.5.2 Geomembrane and Geotextile Selection

The specifications of the geotextile materials and geomembrane to be used as part of the landfill cover were selected based on several factors:

- Availability of materials.
- Flexibility of materials.
- Physical characteristics of materials, including tensile strength and puncture resistance.

5.5.2.1 Availability of Materials

An advantage of using a VFPE geomembrane as the FML is that this material is supplied by a number of different manufacturers and is readily available in quantities required for the Site. Also, if a future need arises for repair or replacement of this material, it can be readily obtained.

5.5.2.2 Flexibility of Material

VFPE geomembrane is able to conform more easily than HDPE geomembrane. For this reason, it can accommodate differential settlement and deformation during and following installation better than HDPE materials, while still providing adequate strengths for field conditions during and following installation.

5.5.2.3 Physical Properties of Geosynthetics

Calculations (Appendix F) were required in order to check the selected materials' physical properties of the materials versus the required strengths during and following installation. The geotextiles used for cushioning and separation will be 16 oz. non-woven polypropylene and the geomembrane will be a 60 mil VFPE membrane.

6.0 OFF-SITE GROUNDWATER TREATMENT

Two areas of upper aquifer groundwater contamination have been delineated at the ACS Site. The shallow groundwater plume extending approximately 700 feet north from the ACS facility has been termed the North Area and a plume extending approximately 2,000 feet to the south-southeast has been termed the South Area. Localized contamination has been documented in the lower aquifer near monitoring well MW-9. This contamination appears to be a direct result of leakage along the well casing at monitoring well MW-9 and does not appear to be part of a wide spread release into the lower aquifier. The well has been abandoned and replaced with MW-9R. Future monitoring will be used evaluate whether or not the source of lower aquifer impact has been eliminated.

The outer line on Drawing C-1 marks the approximate extent of contamination in the upper aquifer at the site. These areas were formed when groundwater contaminants migrated away from the source areas, after ACS began operations in 1955. The installation of the barrier wall in 1997 cut off further migration of contaminants from the source areas to the groundwater in the North and South Areas. However, these two areas of groundwater contamination remain outside the barrier wall. The primary contaminants in the groundwater are benzene and chloroethane.

6.1 DESCRIPTION OF UPPER AQUIFER CONTAMINATION

The North and South Areas of Groundwater contamination coincide with the historical groundwater flow paths outward from the ACS facility. The North Area of groundwater contamination results from groundwater flow from the source areas inside the ACS facility toward the north and west. The South Area of contamination results from the groundwater flow path from the OFCA and K-P Area to the south, southeast.

Currently, a natural attenuation study is being conducted in both the North and South Areas to evaluate the capacity of naturally occurring processes in the soil and groundwater to attenuate the contaminants within the plume. The type and quantity of data being collected to evaluate the efficacy of monitored natural attenuation as a remedial approach follow the EPA guidance for use of monitored natural attenuation (MNA) (U.S. EPA 1997) (22). Periodic monitoring is being conducted at wells within each affected area and at the edges of each area to document any trends or constants in the groundwater quality and contaminant concentration. The results will be further evaluated by the application of modeling to assess the relative contributions of microbes in the soils, reductive dechlorination, volatilization, and dilution. The natural attenuation study was started during the third quarter of 1997, after the barrier wall was closed, cutting off the original source of the groundwater contamination from further migration to the affected areas.

The natural attenuation study will use data from the baseline investigation and routine monitoring. The baseline investigation was conducted during quarterly groundwater monitoring from June 1997 to March 1998. The routine monitoring began during the June 1998 quarterly groundwater monitoring event and will continue through the June 1999 quarterly groundwater monitoring event. During the study, groundwater samples from monitoring wells in the North Area (MW40, MW48, MW39, and MW38) and monitoring wells in the South Area (MW18, MW45, MW19, and MW41) were collected and analyzed for total organic carbon, biological oxygen demand (BOD), nitrate as nitrogen, nitrite as nitrogen, sulfate, total kjeldahl nitrogen, ammonia-nitrogen, and ortho-phosphate. Field measurements for oxidation/reduction potential, temperature, pH, and dissolved oxygen are also collected from the monitoring wells in both areas.

In addition to the groundwater samples, soil samples were collected and analyzed as part of the baseline investigation. The soil samples were collected from the aquifer at three locations for each plume; downgradient of the plume, within the plume, and at the edge of the plume. The soil samples were analyzed for total organic carbon, nitrate, nitrite, sulfate, total kjeldahl nitrogen, ammonia-nitrogen, ortho-phosphate, pH, and soil moisture holding capacity. In addition, each soil sample underwent comparative enumeration assays for aerobic total heterotrophs, aerobic hydrocarbon (i.e., chloroethane and benzene) degraders, and acridine orange direct counts (for an estimation of the number of all types of micoorganisms). Additional soil samples will be collected during the final groundwater monitoring round and analyzed similarly to the baseline samples.

The results of the field investigation will be used to evaluate the microbial and chemical conditions of the plumes and the potential for intrinsic remediation. In addition, computer modeling will be used to model plume conditions and predict the future disposition of contaminants in each plume.

6.1.1 North Area

Historically, groundwater in the North Area started inside the ACS facility and flowed to the west and north, where it discharged to surface water. To the west, the groundwater discharged into the wetlands within 200 to 500 feet of the ACS facility. Samples collected 800 feet directly west of the ACS facility (MW 46), have showed only trace levels of benzene, indicating the end of the area of contamination. To the north, groundwater discharged to the drainage ditch 400 to 600 feet northwest of the facility. Samples collected north of the ACS facility (from monitoring wells MW 48 and MW 49), have consistently contained elevated levels of benzene (up to approximately 10 ppm) and chloroethane (up to 1 ppm). Monitoring wells located further to the north show that the area of contamination ends in that direction (MW37, MW38, and MW39)

The PGCS was installed specifically to halt the further off-site migration of contaminants to the north and west. Sampling indicates that the PGCS has been successful in capturing the contamination to the west of the ACS facility. However, monitoring results at MW48 and MW49 suggest that an area with benzene concentrations of up to 10 ppm that is beyond the hydraulic influence of the PGCS extraction system.

As discussed in the 30 % RD (7), the remediation method proposed for this source is enhanced in-situ bioremediation through the addition of oxygen in the subsurface using products such as Oxygen Release Compound (ORC®). ORC® is a formulation of magnesium peroxide that slowly releases molecular oxygen when hydrated (over 6 to 12 months). The released oxygen enhances the naturally-occurring attenuation process in the zone of contamination. The oxygen introduced into the groundwater by ORC® promotes microbial growth and maximizes the ability of aerobic microbes to degrade the contaminants. ORC® has been used successfully at many sites throughout the United States to treat benzene and chloroethane with no significant reduction in transmissivity through aquifers. The remedial plan includes an ORC® pilot study for treatment of an upper aquifer area with a saturated thickness of 10 feet. The North Area received injections of ORC®, totaling approximately 4,400 pounds (23) during March 1999.

During ORC® injection, eight 2-inch diameter piezometers were installed to monitor remedial progress. Two of the piezometers were installed within the ORC® injection grid, and six of the piezometers were installed up-, down-, and side-gradient of the grid. These piezometers will be sampled and analyzed for benzene, chloroethane, and dissolved oxygen. The frequency of sampling will be prior to injection, six weeks after injection, and monthly thereafter for twelve months.

Data obtained from the quarterly sampling and monitoring will be utilized in conjunction with the natural attenuation investigation to determine the effectiveness of ORC® in reducing benzene concentrations within the North Area. If the ORC® treatment, in conjunction with MNA, is not effective at reducing concentrations within the North Area such that the concentrations within the plume will be reduced to less than MCLs within a reasonable time frame, the ORC® application may be expanded, or other active measures will be evaluated. For instance, the PGCS could be expanded to include the "source" area within the North Area plume.

6.1.2 South Area

An area of benzene and chloroethane contamination extends approximately 2000 feet beyond the barrier wall towards the south-southeast in the upper aquifer. The historical monitoring data indicate contaminant concentrations are generally below 1 ppm in this area. Sampling results from monitoring wells MW41, MW42, MW43, MW44, and MW47, show that the extent of the contaminated areas has been defined. A large portion of this plume area is located in what is essentially a low-lying wetlands area and agriculture production fields, which is conducive to the microbial activity integral to natural attenuation. Decreases have already been noted in the benzene and chloroethane concentrations inside the South Area of contamination.

An investigation into the potential source areas for this benzene/chloroethane plume was conducted in 1996. Geoprobe groundwater samples were collected in an area directly south of the current barrier wall location. These samples indicated a relatively small area (~200' x 50') in which benzene concentrations are between 1 and 8 ppm.

By the beginning of the year 2000, the natural attenuation study will have been completed and active ORC® pilot study will have been conducted in the North Area for one year. If the results of the natural attenuation study and ORC® pilot study monitoring in the North Area indicate that natural attenuation enhanced by ORC® will reduce benzene concentrations in the North Area to MCLs within a reasonable time frame, U.S.EPA may be petitioned to allow ORC® to be used in a similar manner in the South Area. If the ORC® study is unsuccessful in the North Area, and MNA sampling indicates that further active remediation is required in the South Area, an alternative approach for active remediation in the South Area may be necessary, and would be developed and presented to the Agencies for review at that time.

7.0 PROPOSED PROJECT SEQUENCING

Because of the complexity of the project, and the interaction of the various components, a project sequence that illustrates the approximate time frames for each of the remedial components has been developed. The attached Figure 1 illustrates the dependence of certain components on others. For instance, the ISVE system in the Still-Bottoms Pond Area can be installed, but cannot be operated before the dewatering in this area is complete; the covering of the SBPA cannot be finished before the Fire Pond is filled; the Fire Pond cannot be completely filled before the contaminated soils are excavated from the ONCA Drum Removal. This schedule is intended to show the sequence of operations only. Detailed construction schedules for each task and for the project overall will be developed following approval of this Final Remedy Design.

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TABLES

Table 1
Influent Sources to Groundwater Treatment Plant
ACS NPL Site
Griffith, Indiana

Group	Description	Extraction Points
1	PGCS Extraction System	PGCS
2	Groundwater from Existing On-Site Extraction Trenches	EW-10, EW-17, EW-18
3	Groundwater from Dual Phase Extraction Wells in SBP Area	SBP Area Extraction Wells
4	Groundwater from Existing Extraction Trenches on East Side of Off-Site Area	EW-15, EW-16, EW-19
5	Groundwater from Existing Extraction Trenches on West Side of Off-Site Area	EW-11, EW-12, EW-13A (Note 1,2)
6	New Off-Site Extraction Well (EW-20) and Existing Extraction Wells on the West Side of the Off-Site Area	EW-11, EW-12, EW-13, EW-20 (Note 1)
7	ISVE Condensate from SBP Area ISVE System	SBP Area ISVE Knockout Tank
8	ISVE Condensate from OFCA and K-P Area ISVE Systems	OFCA ISVE Knockout Tank

Notes:

1. Extraction Wells EW-11, EW-12, and EW-13 will be valved to discharge to either Source #5 or #6 depending on either hydraulic or contaminant loadings.
2. EW-13A will replace the existing EW-13

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Table 2
HELP Model Results:
SBPA and OFCA Engineered and Surrounding Final Cover Designs
American Chemical Service, Inc. NPL Site
Griffith, Indiana

Engineered and Surrounding Cover Design Description		Average Annual Totals		Peak Daily Values	
		Inches	Cubic Feet	Inches	Cubic Feet
SBPA Engineered Cover	(4" asphalt, 6" compacted gravel, geotextile fabric, 12" compacted clay soil (CL))				
Precipitation		34.15	359,451.80	4.64	48,845.28
Runoff		19.42	204,459.69	4.23	44,573.34
Evapotranspiration		14.52	152,837.83	--	--
Percolation Through Cover		0.21	2,179.20	0.00	47.32
OFCA Engineered Cover	(6" OL, 12" ML, geotextile fabric, 60-mil FML, 12" compacted clay soil (CL))				
Precipitation		34.15	788,314.90	4.64	107,122.75
Runoff		5.17	119,434.30	2.26	52,137.06
Evapotranspiration		28.97	668,743.30	--	--
Percolation Through Cover		0.00005	1.19	0	0.01
OFCA Surrounding Cover	(6"OL, 18"compacted clay soil (CL))				
Precipitation		34.15	1,403,101	4.64	190,665
Runoff		8.03	329,790	3.555	146,065
Evapotranspiration		25.127	1,033,746	--	--
Percolation Through Cover		0.96289	39,567	0.006803	280

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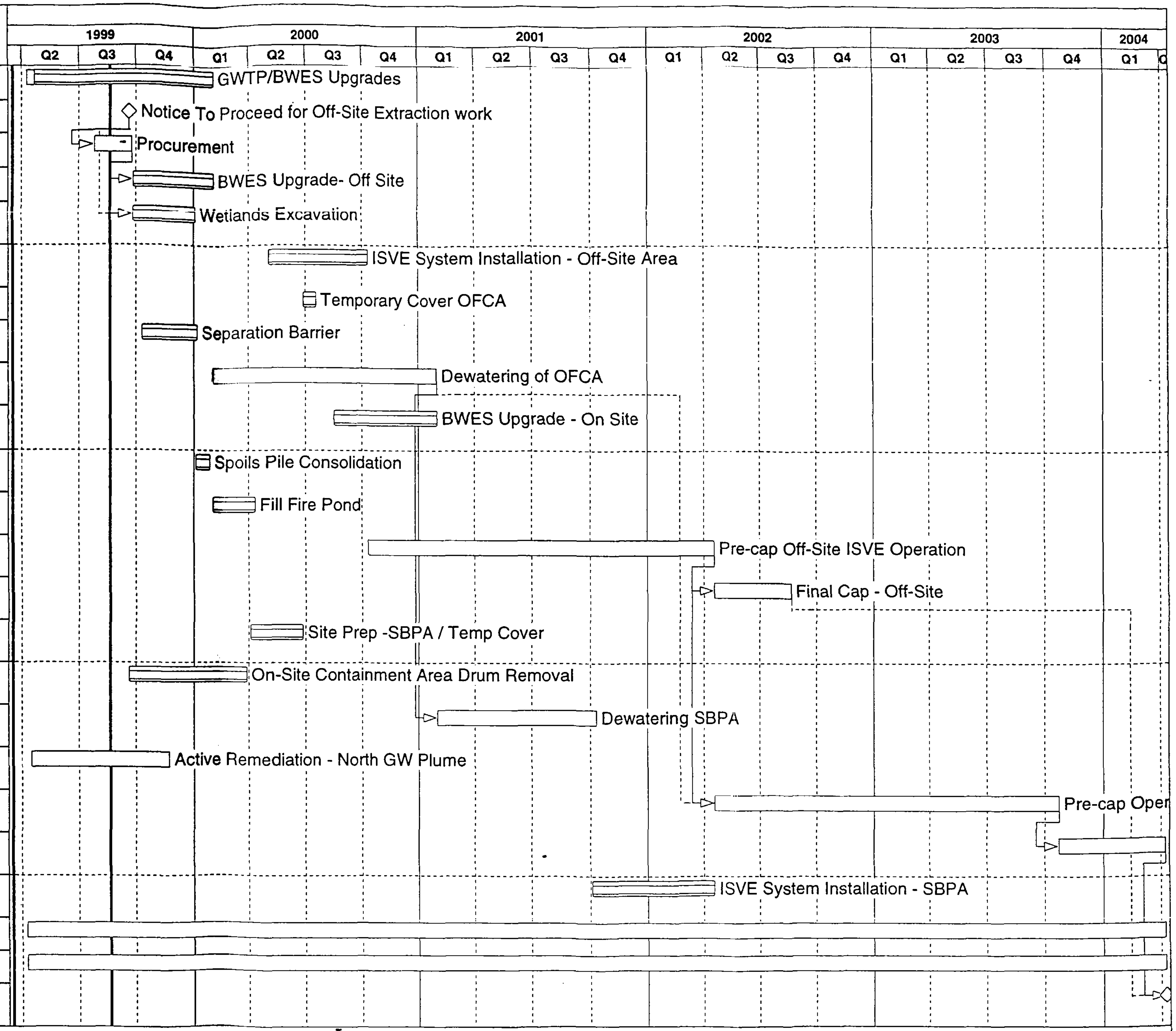
	Description	Rem Dur	Early Start	Early Finish
+	GWTP/BWES Upgrades	205 *	04/09/99 A	02/01/00
	Notice To Proceed for Off-Site Extraction work	0	09/20/99 *	
	Procurement	45	07/26/99	09/24/99
+	BWES Upgrade- Off Site	92 *	09/27/99	02/02/00
+	Wetlands Excavation	71 *	09/27/99	01/03/00
+	ISVE System Installation - Off-Site Area	115 *	05/03/00	10/10/00
+	Temporary Cover OFCA	15 *	06/28/00	07/18/00
+	Separation Barrier	64 *	10/11/99	01/06/00
	Dewatering of OFCA	261	02/02/00	01/31/01
+	BWES Upgrade - On Site	121 *	08/16/00	02/01/01
+	Spoils Pile Consolidation	18 *	01/04/00	01/27/00
+	Fill Fire Pond	50 *	02/02/00	04/11/00
	Pre-cap Off-Site ISVE Operation	396	10/11/00	04/17/02
	Final Cap - Off-Site	90	04/18/02	08/21/02
+	Site Prep -SBPA / Temp Cover	60 *	04/04/00	06/26/00
+	On-Site Containment Area Drum Removal	137 *	09/20/99	03/28/00
	Dewatering SBPA	180	02/01/01	10/10/01
	Active Remediation - North GW Plume	180	04/16/99 A	11/23/99
	Pre-cap Operation- SBPA	396	04/18/02	10/23/03
	Final Cap - SBPA	120	10/24/03	04/08/04
+	ISVE System Installation - SBPA	140 *	10/04/01	04/17/02
	Project Management	1322	04/09/99 A	04/08/04
	Groundwater Monitoring	1322	04/09/99 A	04/08/04
	Begin Long-Term O&M	0	04/09/04	



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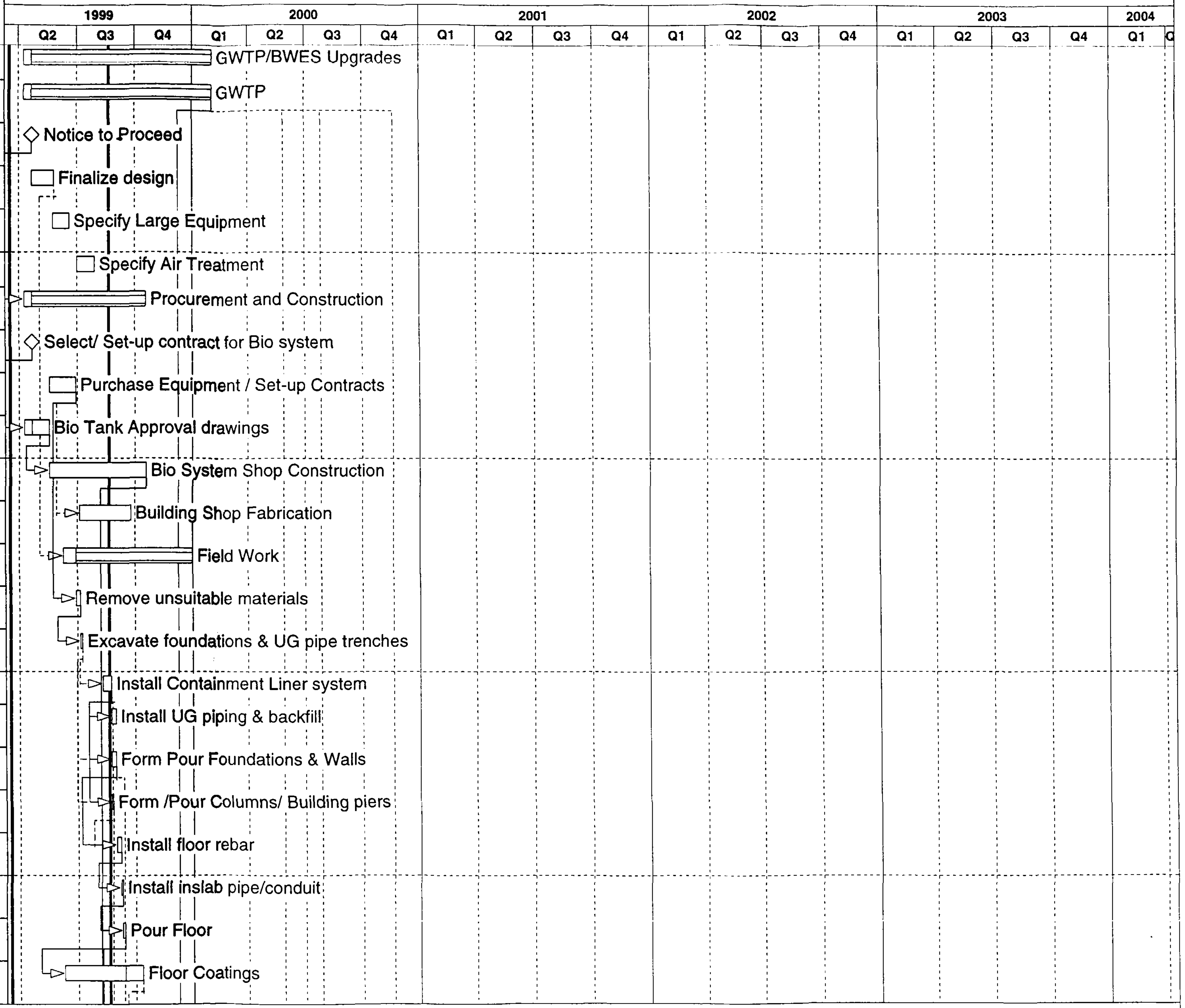
Summary point
Start milestone point
Finish milestone point

Figure 1
ACS R/A Construction Final RD

Date	Revision	Checked	Approved

Note: Dates and timing listed in this schedule are preliminary pending signature on the Consent Decree that will govern the startup and implementation of remediation. The actual start date and dates for major milestones will be modified when the Consent Decree is signed.

Description	Rem Dur	Early Start	Early Finish
GWTP/BWES Upgrades	**205 ***	**04/09/99 A**	**02/01/00**
GWTP	205 *	04/09/99 A	02/01/00
Notice to Proceed	0	04/21/99 *	
Finalize design	25	04/21/99 *	05/25/99
Specify Large Equipment	20	05/24/99 *	06/18/99
Specify Air Treatment	20	07/01/99 *	07/28/99
Procurement and Construction	129 *	04/09/99 A	10/18/99
Select/ Set-up contract for Bio system	0	04/21/99	
Purchase Equipment / Set-up Contracts	30	05/18/99 *	06/28/99
Bio Tank Approval drawings	19	04/09/99 A	05/17/99
Bio System Shop Construction	110	05/18/99	10/18/99
Building Shop Fabrication	60	07/05/99 *	09/24/99
Field Work	134 *	06/09/99 A	12/31/99
Remove unsuitable materials	5	06/29/99	07/05/99
Excavate foundations & UG pipe trenches	3	07/06/99	07/08/99
Install Containment Liner system	10	08/10/99 *	08/23/99
Install UG piping & backfill	5	08/24/99	08/30/99
Form Pour Foundations & Walls	5	08/24/99	08/30/99
Form /Pour Columns/ Building piers	2	08/24/99	08/25/99
Install floor rebar	5	08/31/99	09/06/99
Install inslab pipe/conduit	3	09/07/99	09/09/99
Pour Floor	2	09/10/99	09/13/99
Floor Coatings	20	06/09/99 A	10/11/99



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Critical bar
Summary bar
Progress point
Critical point
Summary point
Start milestone point
Finish milestone point

Figure 1
ACS R/A Construction Final RD

Date	Revision	Checked	Approved

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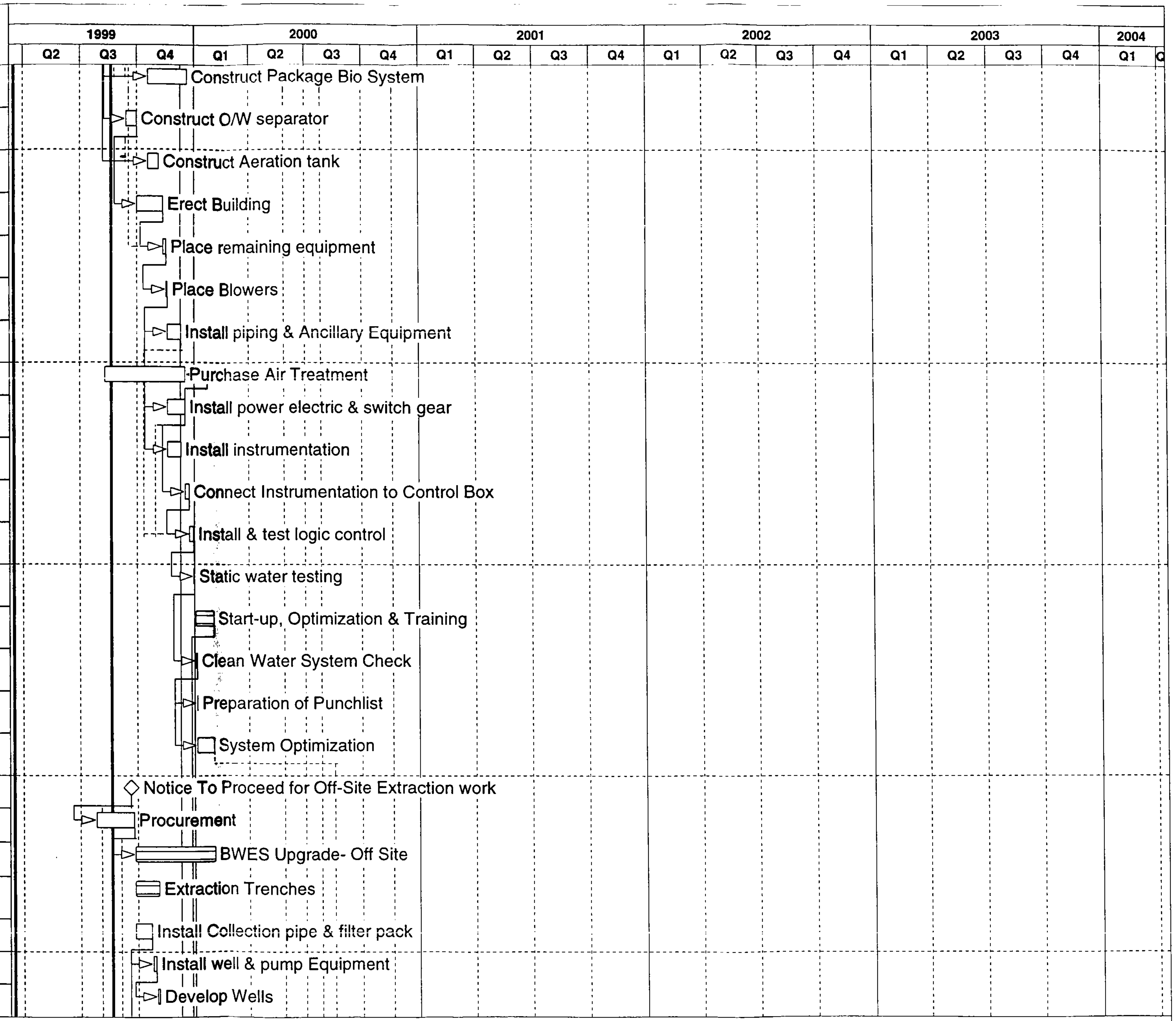
Description	Rem Dur	Early Start	Early Finish
Construct Package Bio System	45	10/19/99	12/20/99
Construct O/W separator	13	09/14/99	09/30/99
Construct Aeration tank	13	10/19/99	11/04/99
Erect Building	30	10/01/99	11/11/99
Place remaining equipment	3	11/12/99	11/16/99
Place Blowers	2	11/17/99	11/18/99
Install piping & Ancillary Equipment	15	11/19/99	12/09/99
Purchase Air Treatment	93	08/10/99 *	12/16/99
Install power electric & switch gear	20	11/19/99	12/16/99
Install instrumentation	15	11/19/99	12/09/99
Connect Instrumentation to Control Box	5	12/17/99	12/23/99
Install & test logic control	5	12/24/99	12/30/99
Static water testing	1	12/31/99	12/31/99
Start-up, Optimization & Training	22 *	01/03/00	02/01/00
Clean Water System Check	2	01/03/00 *	01/04/00
Preparation of Punchlist	1	01/05/00	01/05/00
System Optimization	20	01/05/00	02/01/00
Notice To Proceed for Off-Site Extraction work	**0**	**09/20/99 ***	
Procurement	**45**	**07/26/99**	**09/24/99**
BWES Upgrade- Off Site	**92 ***	**09/27/99**	**02/02/00**
Extraction Trenches	28 *	09/27/99	11/03/99
Install Collection pipe & filter pack	20	09/27/99 *	10/22/99
Install well & pump Equipment	5	10/25/99	10/29/99
Develop Wells	3	11/01/99	11/03/99



Finish date	04/08/04
Data date	03/17/99
Run date	08/19/99
Page number	2A

Early bar
Progress bar
Critical bar
Summary bar
Progress point
Critical point
Summary point
Start milestone point
Finish milestone point

Figure 1
ACS R/A Construction Final RD

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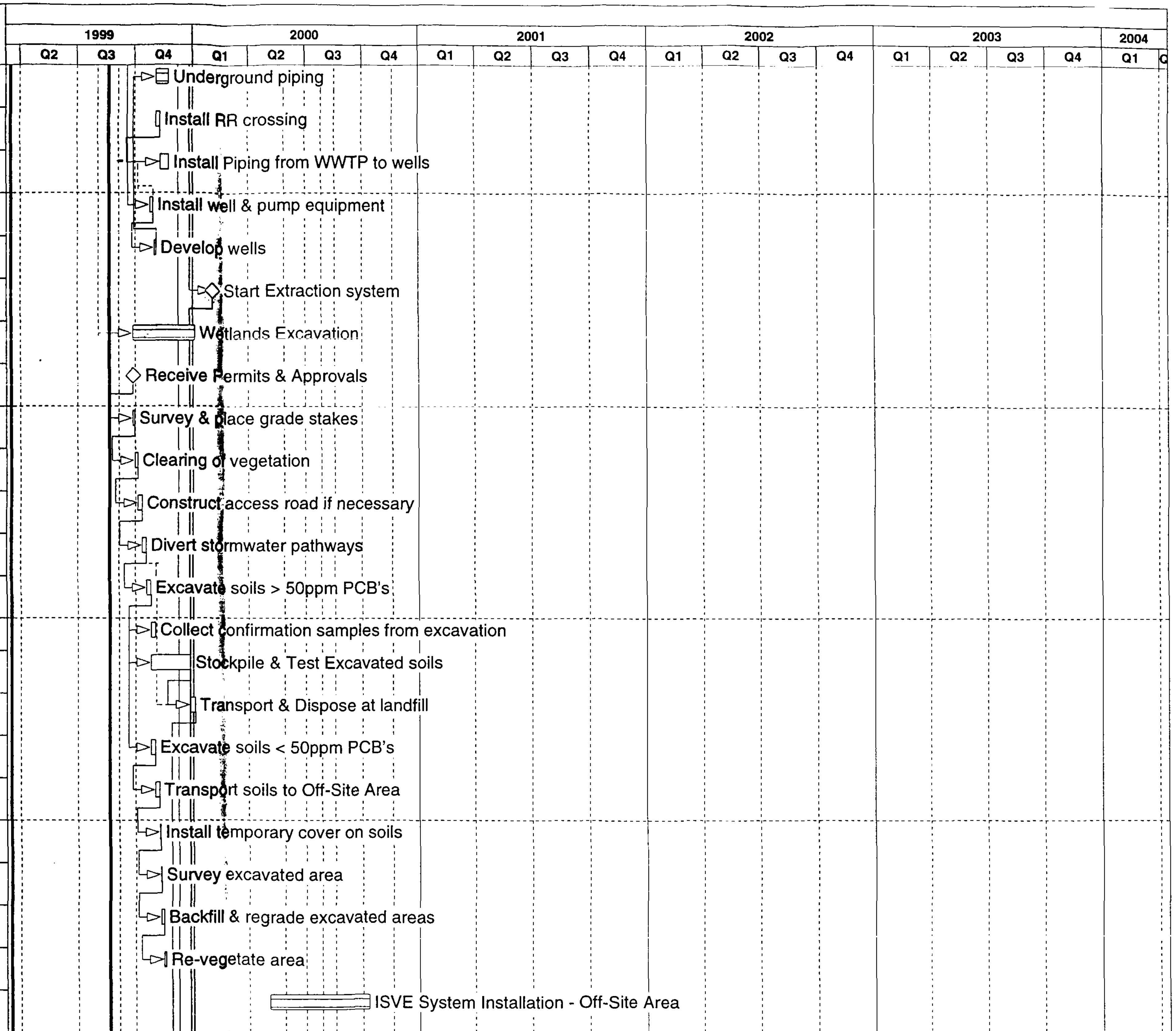
Description	Rem Dur	Early Start	Early Finish
Underground piping	15 *	11/04/99	11/24/99
Install RR crossing	5	11/04/99	11/10/99
Install Piping from WWTP to wells	10	11/11/99	11/24/99
Install well & pump equipment	5	10/25/99	10/29/99
Develop wells	3	11/01/99	11/03/99
Start Extraction system	0	02/02/00	
Wetlands Excavation	**71 ***	**09/27/99**	**01/03/00**
Receive Permits & Approvals	0	09/27/99 *	
Survey & place grade stakes	3	09/27/99	09/29/99
Clearing of vegetation	3	09/30/99	10/04/99
Construct access road if necessary	5	10/05/99	10/11/99
Divert stormwater pathways	5	10/12/99	10/18/99
Excavate soils > 50ppm PCB's	5	10/19/99	10/25/99
Collect confirmation samples from excavation	5	10/26/99	11/01/99
Stockpile & Test Excavated soils	45	10/26/99	12/27/99
Transport & Dispose at landfill	5	12/28/99	01/03/00
Excavate soils < 50ppm PCB's	5	10/26/99	11/01/99
Transport soils to Off-Site Area	5	11/02/99	11/08/99
Install temporary cover on soils	1	11/09/99	11/09/99
Survey excavated area	1	11/10/99	11/10/99
Backfill & regrade excavated areas	3	11/11/99	11/15/99
Re-vegetate area	3	11/16/99	11/18/99
ISVE System Installation - Off-Site Area	**115 ***	**05/03/00**	**10/10/00**



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Run date	08/19/99
Page number	3A

Early bar
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Summary bar
△ Progress point
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Summary point
◇ Start milestone point
◇ Finish milestone point

Figure 1
ACS R/A Construction Final RD

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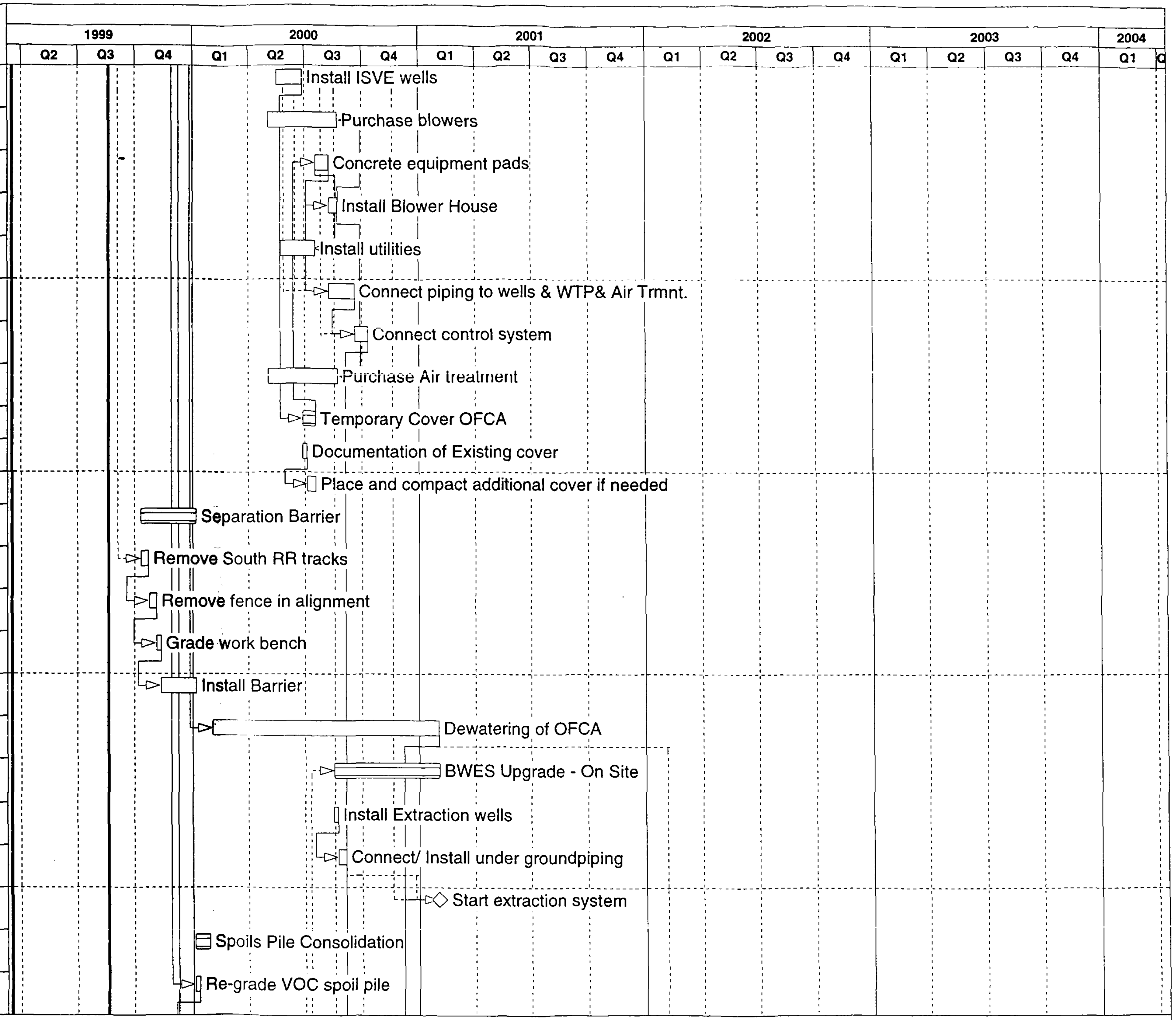
Description	Rem Dur	Early Start	Early Finish
Install ISVE wells	30	05/17/00 *	06/27/00
Purchase blowers	80	05/03/00	08/22/00
Concrete equipment pads	15	07/19/00	08/08/00
Install Blower House	10	08/09/00	08/22/00
Install utilities	40	05/24/00	07/18/00
Connect piping to wells & WTP& Air Trmnt.	30	08/09/00	09/19/00
Connect control system	15	09/20/00	10/10/00
Purchase Air treatment	80	05/03/00	08/22/00
Temporary Cover OFCA	**15 ***	**06/28/00**	**07/18/00**
Documentation of Existing cover	5	06/28/00	07/04/00
Place and compact additional cover if needed	10	07/05/00	07/18/00
Separation Barrier	**64 ***	**10/11/99**	**01/06/00**
Remove South RR tracks	10	10/11/99 *	10/22/99
Remove fence in alignment	9	10/25/99	11/04/99
Grade work bench	5	11/05/99	11/11/99
Install Barrier	40	11/12/99	01/06/00
Dewatering of OFCA	**261**	**02/02/00**	**01/31/01**
BWES Upgrade - On Site	**121 ***	**08/16/00**	**02/01/01**
Install Extraction wells	5	08/16/00 *	08/22/00
Connect/ Install under groundpiping	9	08/23/00 *	09/04/00
Start extraction system	0	02/01/01	
Spoils Pile Consolidation	**18 ***	**01/04/00**	**01/27/00**
Re-grade VOC spoil pile	5	01/04/00	01/10/00



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Page number	4A

Early bar
Progress bar
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Progress point
Critical point
Summary point
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ACS R/A Construction Final RD

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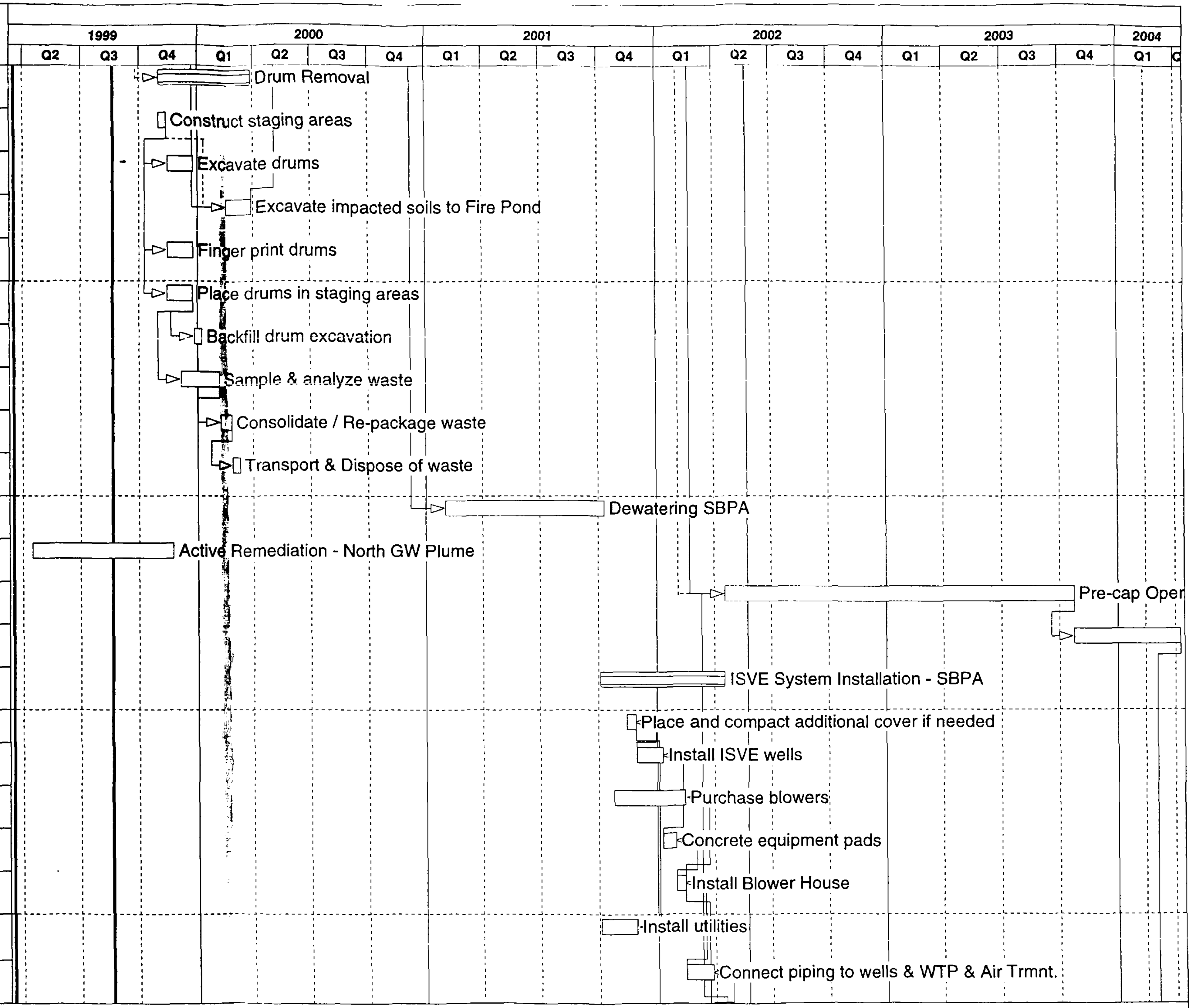
Description	Rem Dur	Early Start	Early Finish
Drum Removal	107 *	11/01/99	03/28/00
Construct staging areas	10	11/01/99 *	11/12/99
Excavate drums	30	11/15/99	12/24/99
Excavate impacted soils to Fire Pond	30	02/16/00	03/28/00
Finger print drums	30	11/15/99	12/24/99
Place drums in staging areas	30	11/15/99	12/24/99
Backfill drum excavation	10	12/27/99	01/07/00
Sample & analyze waste	45	12/06/99	02/04/00
Consolidate / Re-package waste	15	02/07/00	02/25/00
Transport & Dispose of waste	10	02/28/00	03/10/00
Dewatering SBPA	**180**	**02/01/01**	**10/10/01**
Active Remediation - North GW Plume	**180**	**04/16/99 A**	**11/23/99**
Pre-cap Operation- SBPA	**396**	**04/18/02**	**10/23/03**
Final Cap - SBPA	**120**	**10/24/03**	**04/08/04**
ISVE System Installation - SBPA	**140 ***	**10/04/01**	**04/17/02**
Place and compact additional cover if needed	10	11/15/01 *	11/28/01
Install ISVE wells	30	11/29/01	01/09/02
Purchase blowers	80	10/25/01	02/13/02
Concrete equipment pads	15	01/10/02	01/30/02
Install Blower House	10	01/31/02	02/13/02
Install utilities	40	10/04/01	11/28/01
Connect piping to wells & WTP & Air Trmnt.	30	02/14/02	03/27/02



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Page number	6A

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- ◇ Start milestone point
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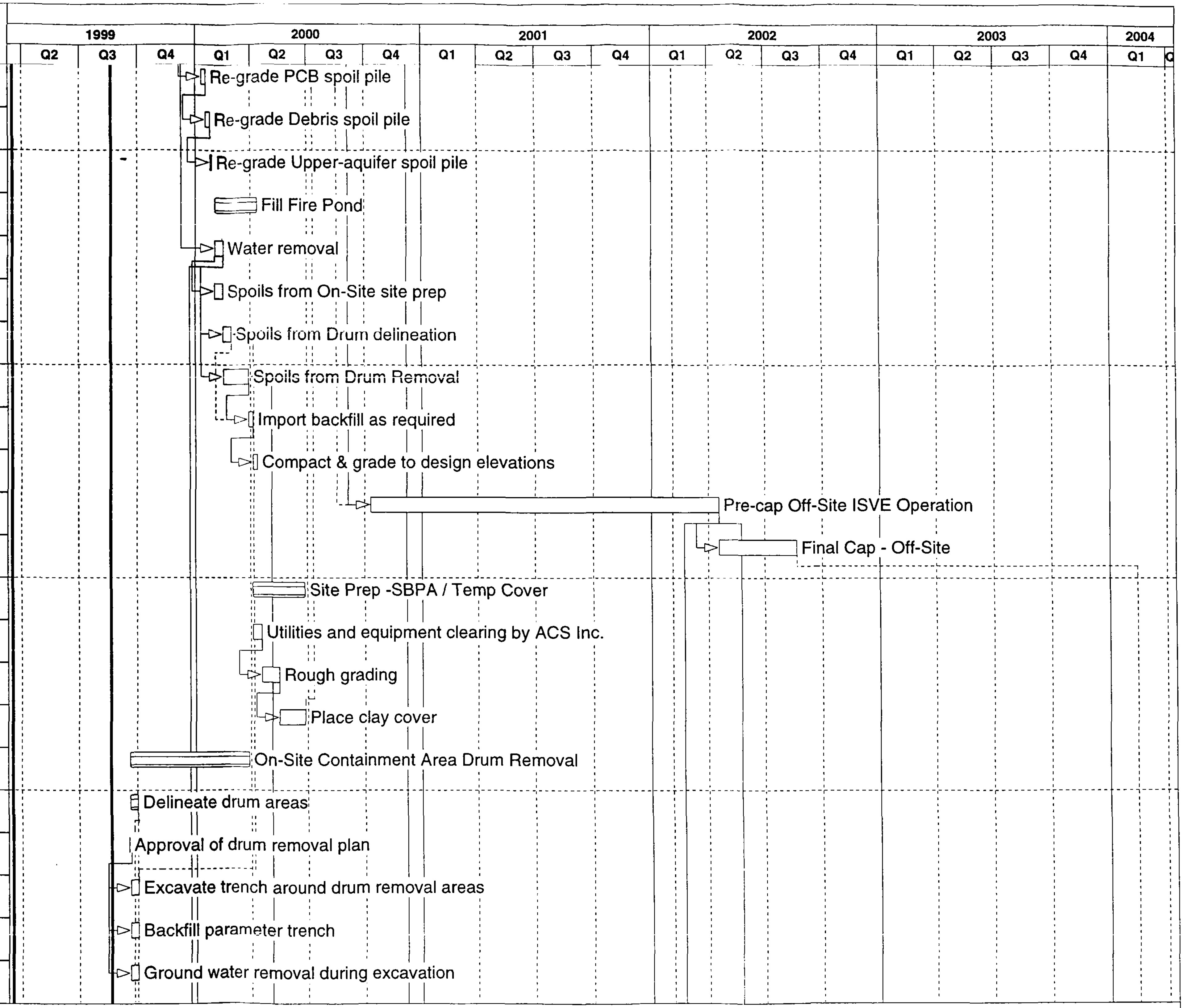
Description	Rem Dur	Early Start	Early Finish
Re-grade PCB spoil pile	5	01/11/00	01/17/00
Re-grade Debris spoil pile	5	01/18/00	01/24/00
Re-grade Upper-aquifer spoil pile	3	01/25/00	01/27/00
Fill Fire Pond	**50 ***	**02/02/00**	**04/11/00**
Water removal	10	02/02/00	02/15/00
Spoils from On-Site site prep	10	02/02/00	02/15/00
Spoils from Drum delineation	10	02/16/00	02/29/00
Spoils from Drum Removal	30	02/16/00	03/28/00
Import backfill as required	5	03/29/00	04/04/00
Compact & grade to design elevations	5	04/05/00	04/11/00
Pre-cap Off-Site ISVE Operation	**396**	**10/11/00**	**04/17/02**
Final Cap - Off-Site	**90**	**04/18/02**	**08/21/02**
Site Prep -SBPA / Temp Cover	**60 ***	**04/04/00**	**06/26/00**
Utilities and equipment clearing by ACS Inc.	10	04/04/00 *	04/17/00
Rough grading	20	04/18/00	05/15/00
Place clay cover	30	05/16/00	06/26/00
On-Site Containment Area Drum Removal	**137 ***	**09/20/99**	**03/28/00**
Delineate drum areas	10 *	09/20/99 *	10/01/99
Approval of drum removal plan	0	09/20/99	09/17/99
Excavate trench around drum removal areas	10	09/20/99	10/01/99
Backfill parameter trench	10	09/20/99	10/01/99
Ground water removal during excavation	10	09/20/99	10/01/99



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Page number	5A

Early bar
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Summary point
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ACS R/A Construction Final RD

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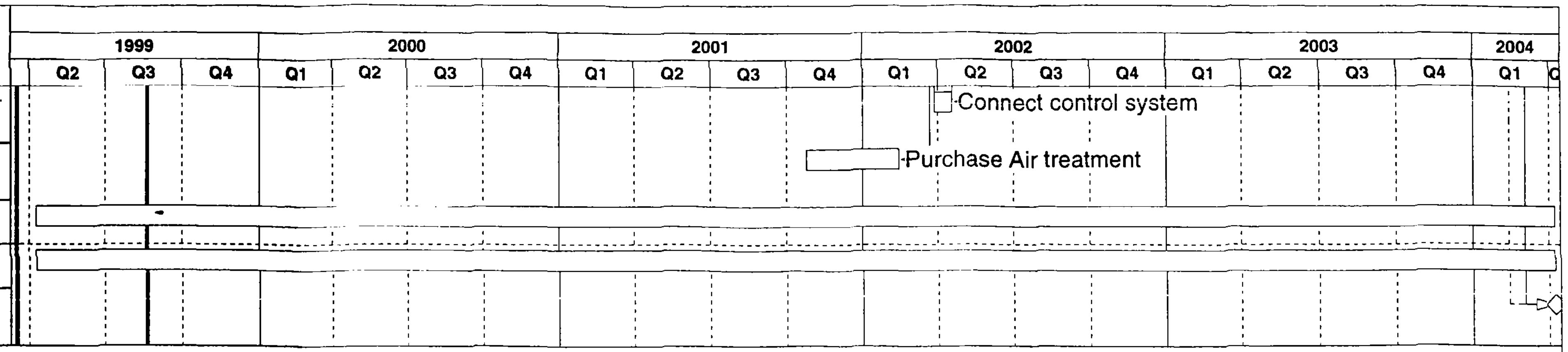
Description	Rem Dur	Early Start	Early Finish
Connect control system	15	03/28/02	04/17/02
Purchase Air treatment	80	10/25/01	02/13/02
Project Management	**1322**	**04/09/99 A**	**04/08/04**
Groundwater Monitoring	**1322**	**04/09/99 A**	**04/08/04**
Begin Long-Term O&M	**0**	**04/09/04**	



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Page number	7A

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ACS R/A Construction Final RD

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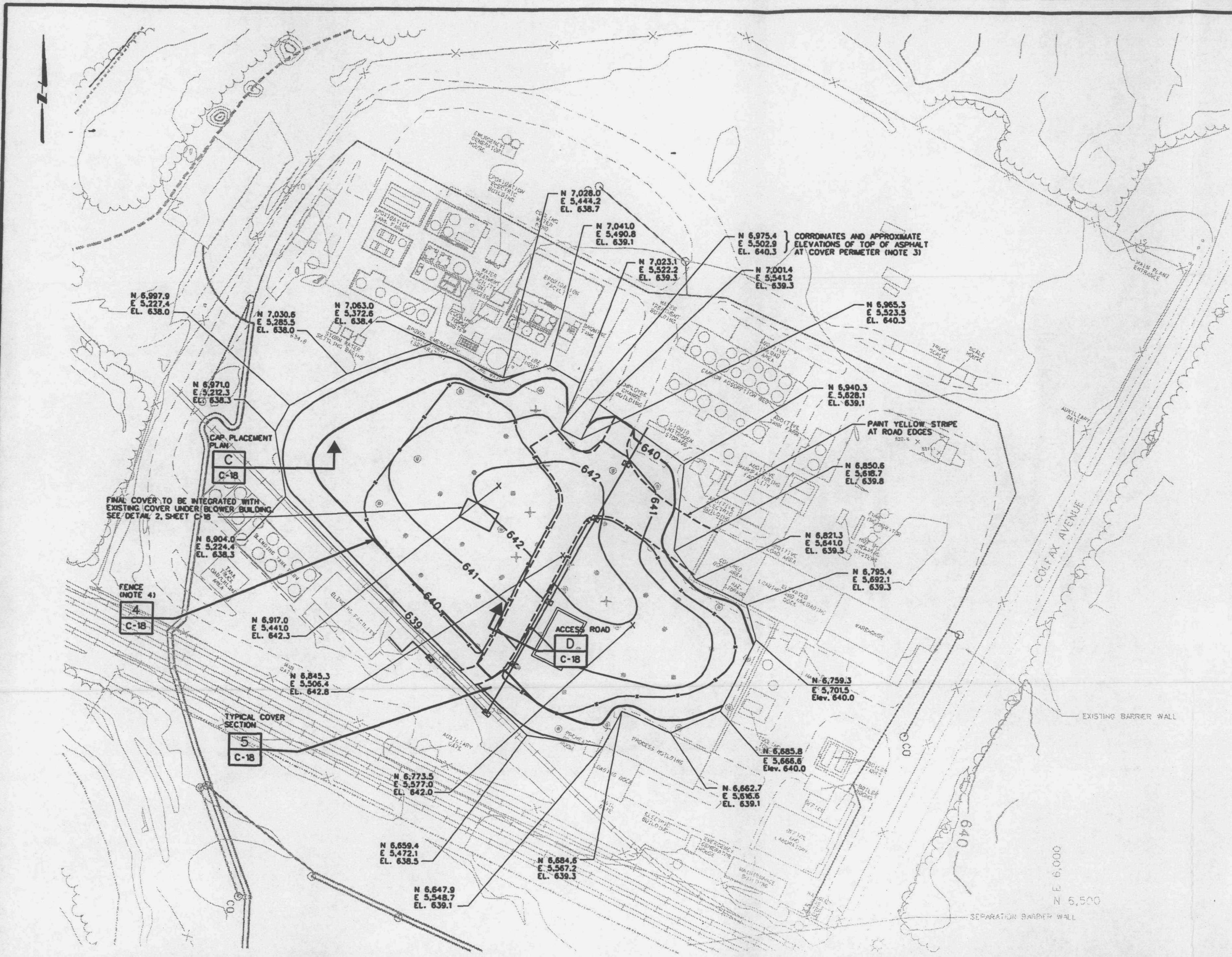
APPENDICES

A



LEGEND:

—640—	TOP OF ASPHALT CONTOUR ELEVATION
●	ISVE WELL LOCATION
◉	DUAL PHASE WELL LOCATION
✛	AIR SPARGE POINT
—x——x—	POST-AND-CHAIN FENCE

THOMAS A. BLAIR REGISTERED NO. 9600482 STATE OF INDIANA PROFESSIONAL ENGINEER

expires 7/31/00

signature

8/20/99

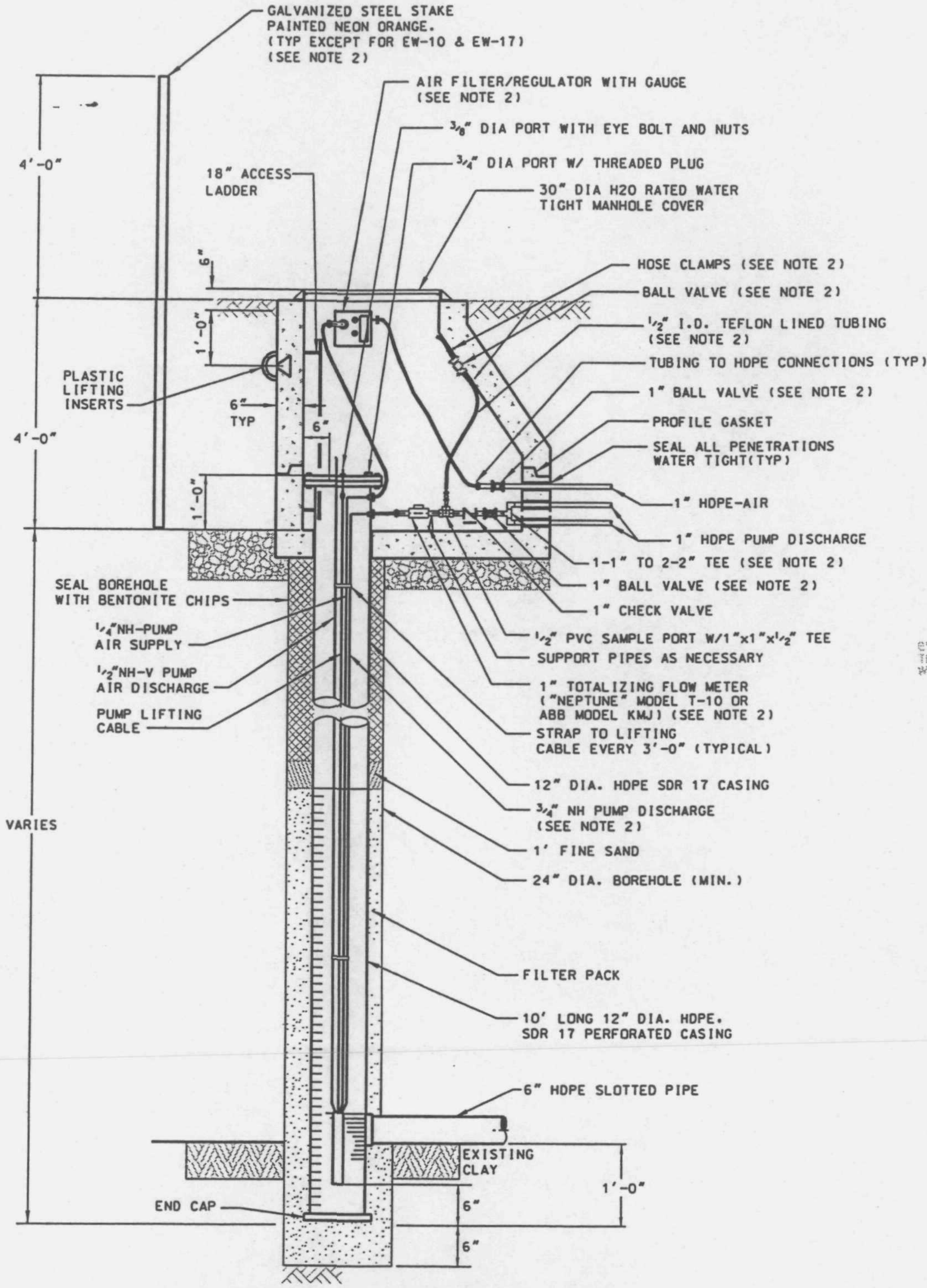
date

NOTES:

1. CONTOURS SHOWN FOR GRAPHICAL REPRESENTATION ONLY. COORDINATES WILL GOVERN GRADING AND SURVEY LAYOUT.
2. ASPHALT PLACEMENT NEAR BUILDINGS AND TANK PAD TO BE DONE SO AS NOT TO DAMAGE ANY EXISTING STRUCTURE OR FOUNDATION.
3. ELEVATIONS OF PERIMETER CONTROL POINTS SHOWN ARE APPROXIMATE. COVER ELEVATIONS TO MATCH EXISTING GROUND SURFACE AT PERIMETER.
4. FENCE LOCATION SHOWN IS APPROXIMATE. ACTUAL LOCATION TO BE DETERMINED AND LAID OUT IN THE FIELD DURING CONSTRUCTION.

Job No: MW Job # File: J:/1252/042/28/civ/acs28c06.dgn Plot Date: $$$$date$$$$ $$time$$

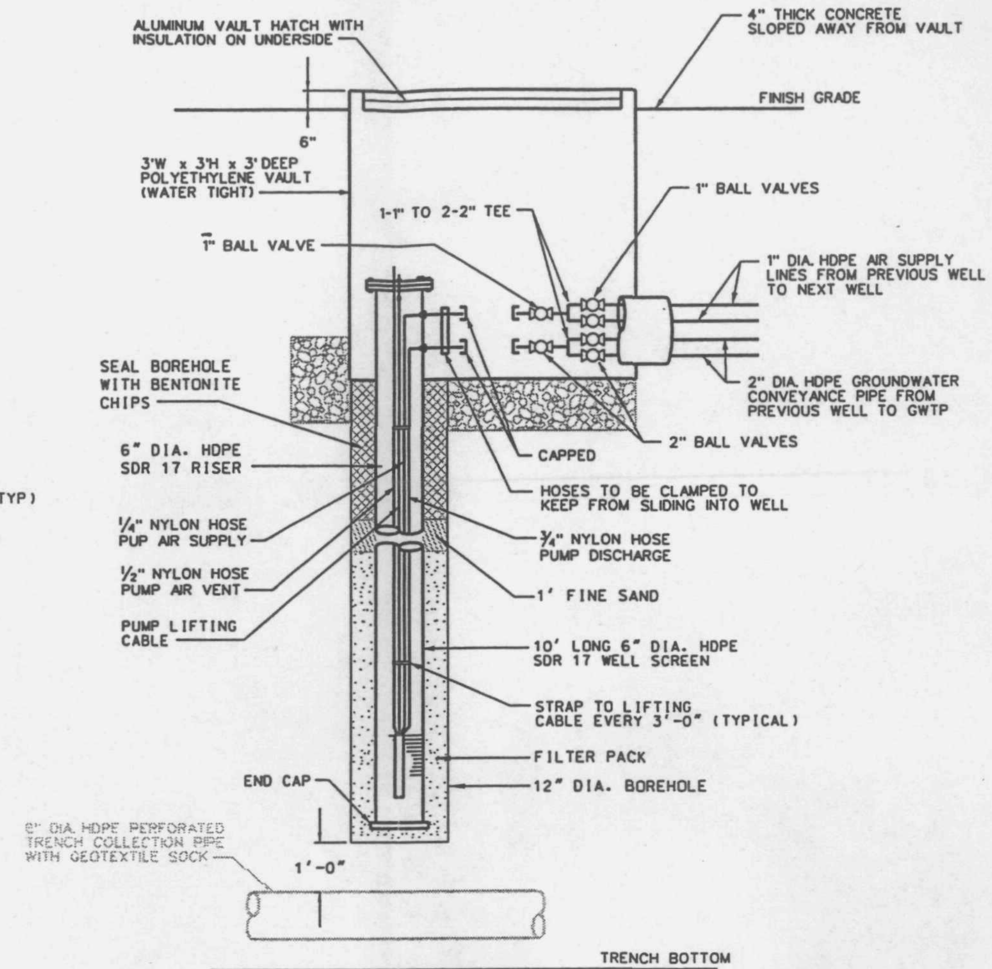
REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY						
				1" = 50'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED TAB / DRAWN RBA / CHECKED	TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE / (COMPANY OFFICER) LICENSE NO. DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN STILL BOTTOMS POND AREA COVER TOP OF ASPHALT CONTOURS	SHEET C-14		



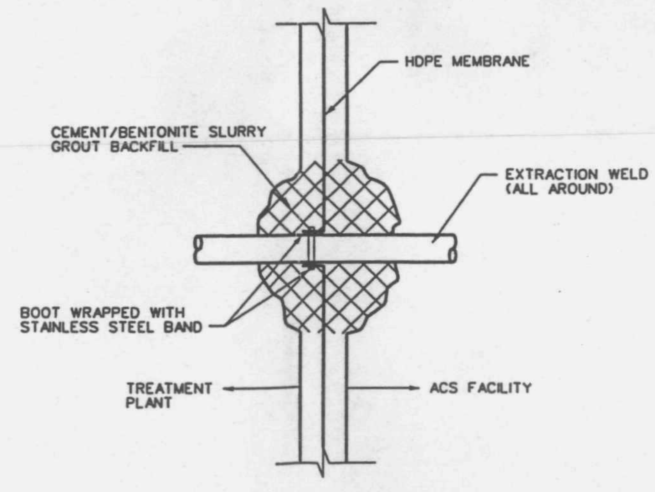
END EXTRACTION WELL DETAIL 1 / C-2
NOT TO SCALE

NOTES:

1. NH=NYLON HOSE
2. EXTRACTION WELLS EW-10, EW-11, EW-12, EW-15, EW-16, EW-17 AND EW-18 REQUIRE INSTALLATION OF THIS EQUIPMENT ONLY.

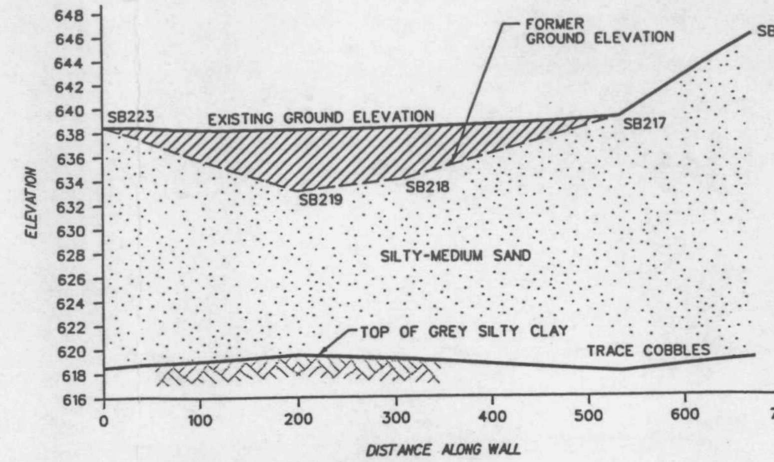


IN-LINE EXTRACTION WELL HEAD 2 / C-2
NOT TO SCALE

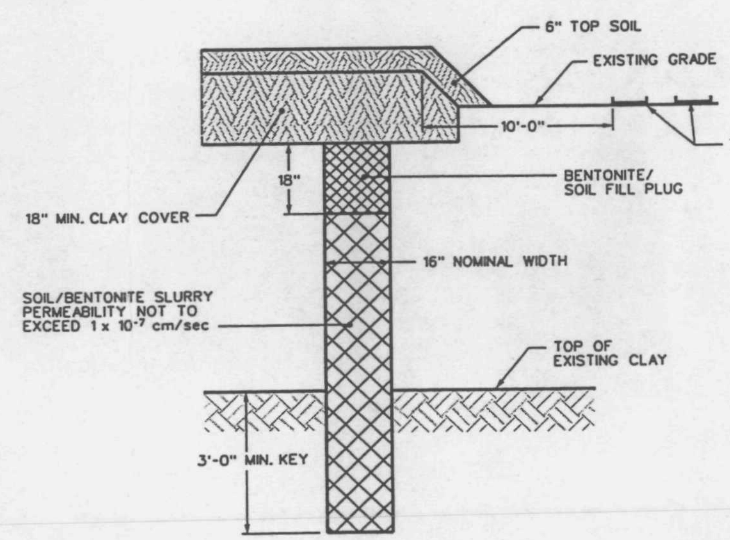


NOTE:
SEE SECTION 4, SHEET C-19 FOR PROFILE OF ALL PIPES.

BARRIER WALL/FORCEMAIN INTERFACE (TYPICAL PIPE) C / C-2
NOT TO SCALE



SEPARATION BARRIER WALL SUBSURFACE SOIL PROFILE A / C-2
NOT TO SCALE



TYPICAL BARRIER WALL SECTION B / C-2
NOT TO SCALE

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00
signature [signature]
8/20/99
date

REV	DATE	BY	DESCRIPTION

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DESIGNED	RAA
DRAWN	RBA
CHECKED	TAB

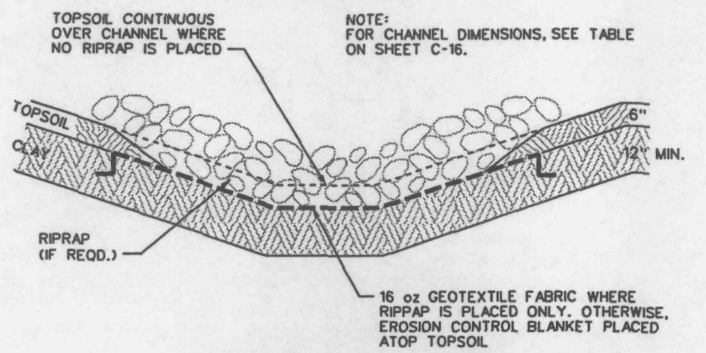
SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) — IN-19600482 LICENSE NO. — DATE
(COMPANY OFFICER) — LICENSE NO. — DATE

MONTGOMERY WATSON
Chicago, Illinois

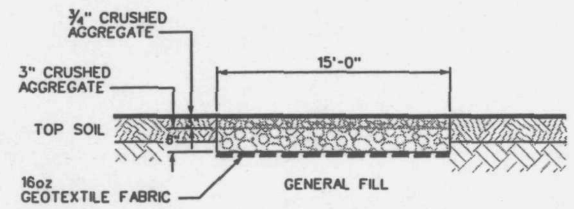
ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
BARRIER WALL EXTRACTION SYSTEM SECTIONS AND DETAILS

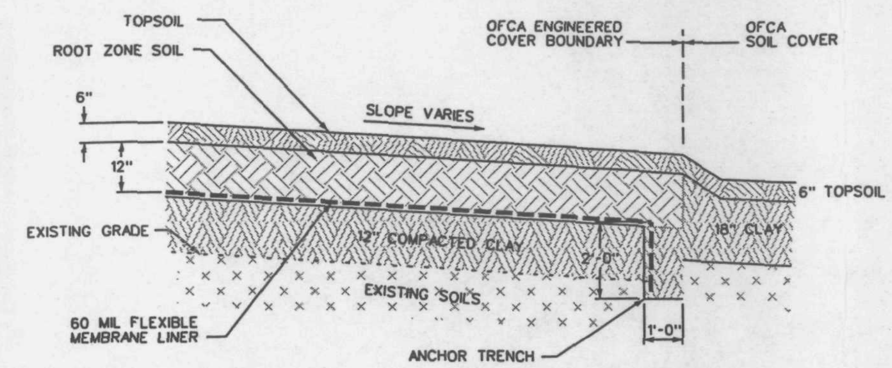
SHEET C-15



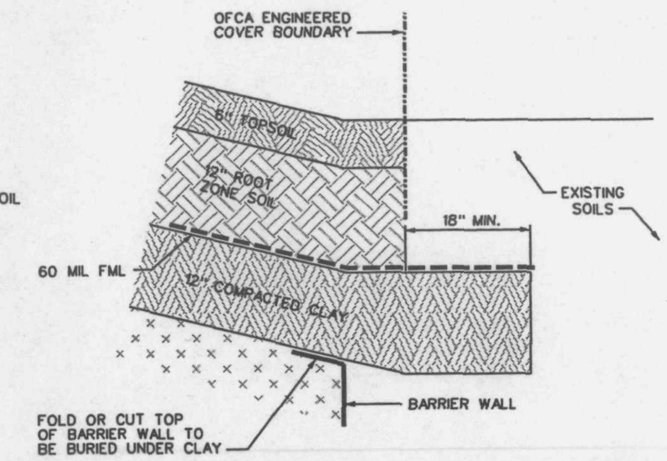
TYPICAL DRAINAGE CHANNEL | A | C-8
NOT TO SCALE



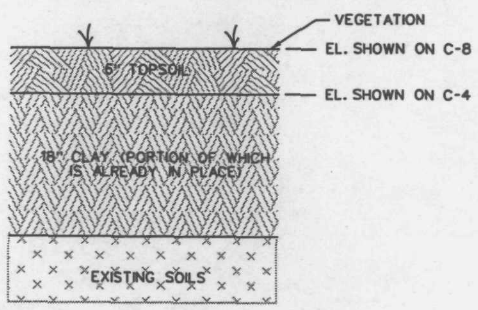
TYPICAL ACCESS ROAD SECTION | B | C-4 | C-8
NOT TO SCALE



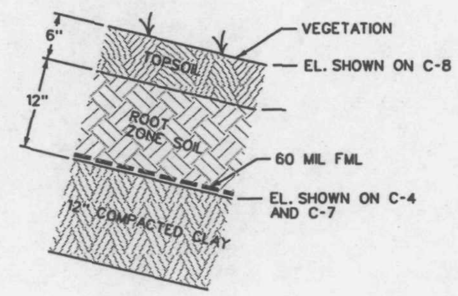
TYPICAL OFCA ENGINEERED COVER ANCHOR SYSTEM | C | C-7
VE-2X



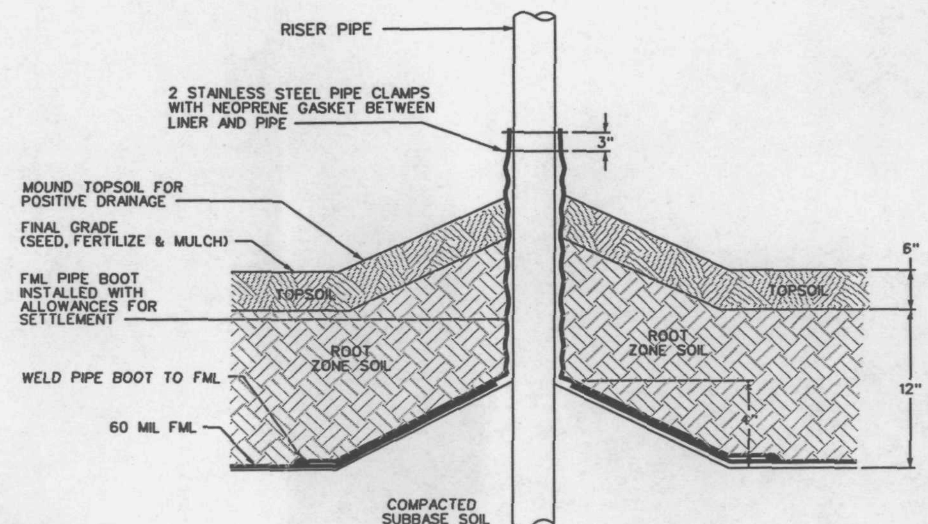
FML ANCHOR TO BARRIER WALL | D | C-7
NOT TO SCALE



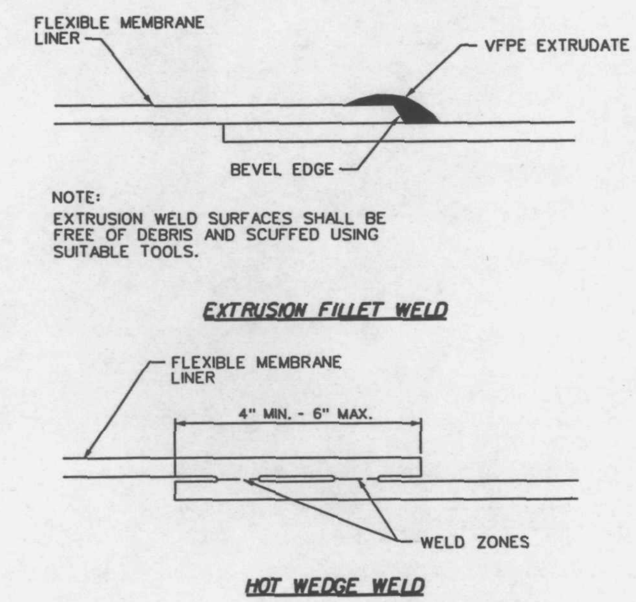
OFCA TYPICAL SOIL COVER SYSTEM | 1 | C-4 | C-7 | C-8
NOT TO SCALE



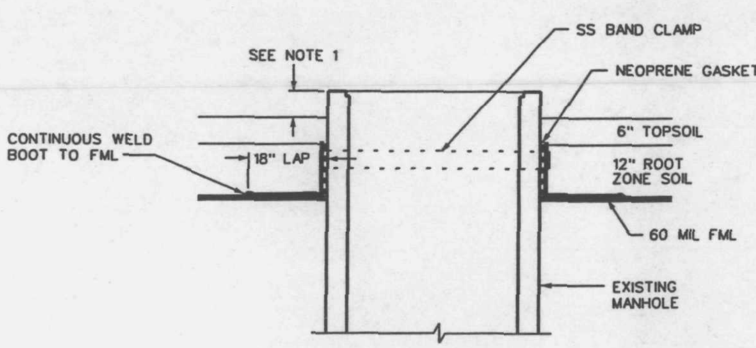
OFF-SITE CONTAINMENT AREA TYPICAL ENGINEERED COVER SYSTEM | 2 | C-4 | C-7 | C-8
NOT TO SCALE



TYPICAL FML PENETRATION DETAIL | 3 | C-7
NOT TO SCALE



VFPE LINER WELDS | 5 | C-7
NOT TO SCALE



NOTE:
1. ELEVATION OF MANHOLE TOP TO BE ADJUSTED TO FINAL GRADE PLUS 6".

FML CONNECTION TO EXISTING MANHOLES | 4 | C-7
NOT TO SCALE

SUMMARY OF DATA RESULTS FOR DESIGNED TRAPEZOIDAL CHANNELS

CHANNEL NO.	DRAINAGE AREA	CHANNEL SLOPE	CHANNEL DEPTH	CHANNEL DIMENSIONS LEFT SIDE SLOPE	CHANNEL DIMENSIONS RIGHT SIDE SLOPE	CHANNEL BASE	CHANNEL VELOCITY	PEAK DISCHARGE ENTERING CHANNEL	MAXIMUM FLOW IN CHANNEL	MANNING'S COEFFICIENT
	(ACRES)	(FT/FT)	(FT)	H:V	H:V	(FT)	(FT/S)	(CFS)	(CFS)	---
1	4.25	0.015	1.0	4.0	4.0	2	4.10	13	24.58	0.035
2	3.31	0.015	1.0	4.0	4.0	2	4.25	14	25.48	0.030
3	1.78	0.019	1.0	4.0	4.0	2	4.10	7	24.58	0.035
4A	0.28	0.019	1.0	4.0	4.0	2	4.78	8	28.67	0.030
4B	2.36	0.019	1.0	4.0	4.0	2	5.44	31	47.59	0.030

TRAPEZOIDAL CHANNEL NOTES:
1) OFCA partitioned into six watershed sections
2) Channels 2, 4A and 4B Manning's Coefficient represents short grass and few weeds
3) Channels 1 and 3 Manning's Coefficient represents rock based on design section
4) Peak discharge entering channel based on 100 year, 24 hour storm event

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER
expires 7/31/00
signature
8/20/99
date

REV	DATE	BY	DESCRIPTION	SCALE: NONE	WARNING: 0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED BPG / DRAWN RBA / CHECKED TAB	SUBMITTED BY: TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE; (COMPANY OFFICER) LICENSE NO. DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN OFCA COVER SECTIONS AND DETAILS	SHEET C-16

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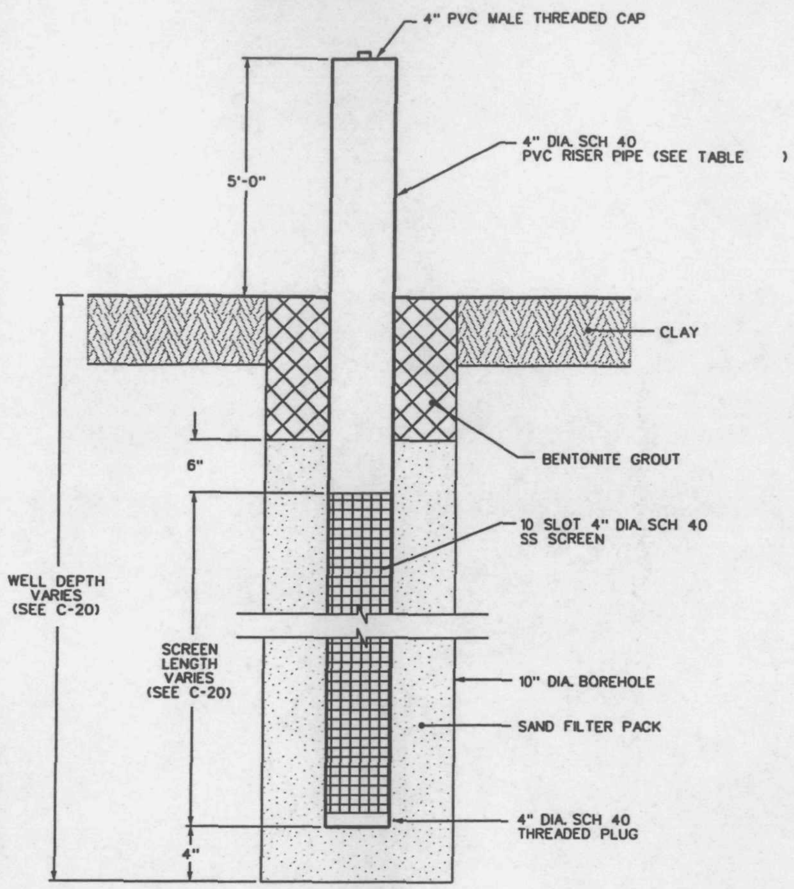
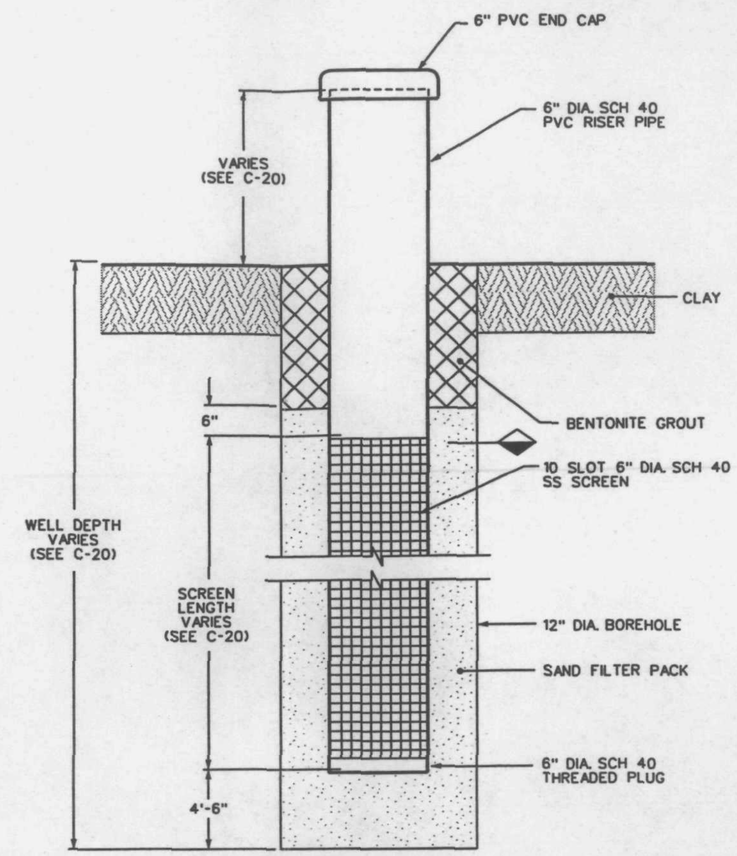


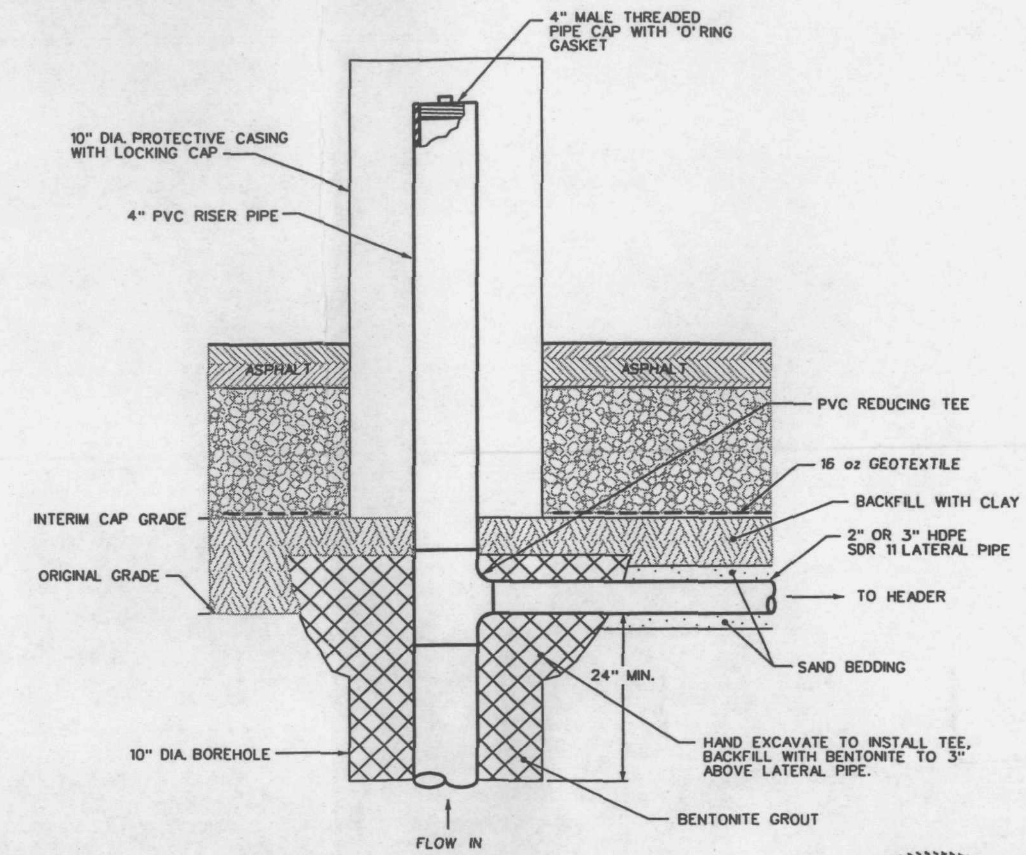
VAPOR EXTRACTION WELL PRELIMINARY CONSTRUCTION
NOT TO SCALE

1 | C-5 | C-6 | C-12



ON-SITE DUAL EXTRACTION WELL PRELIMINARY CONSTRUCTION
NOT TO SCALE

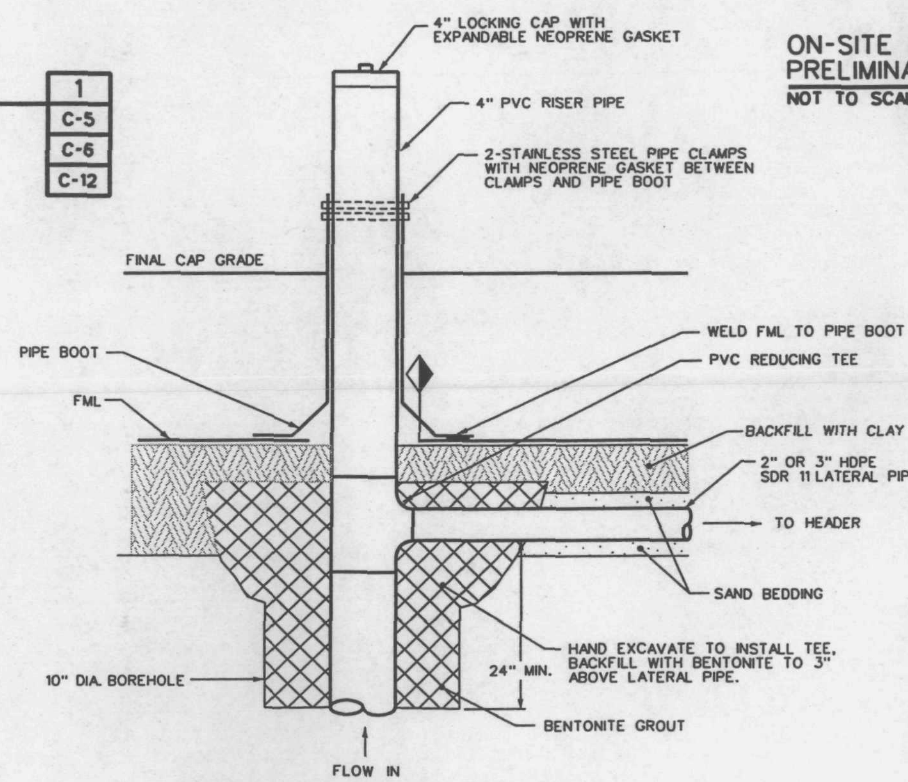
2 | C-12



ON-SITE AREA VAPOR EXTRACTION WELL HEAD
NOT TO SCALE

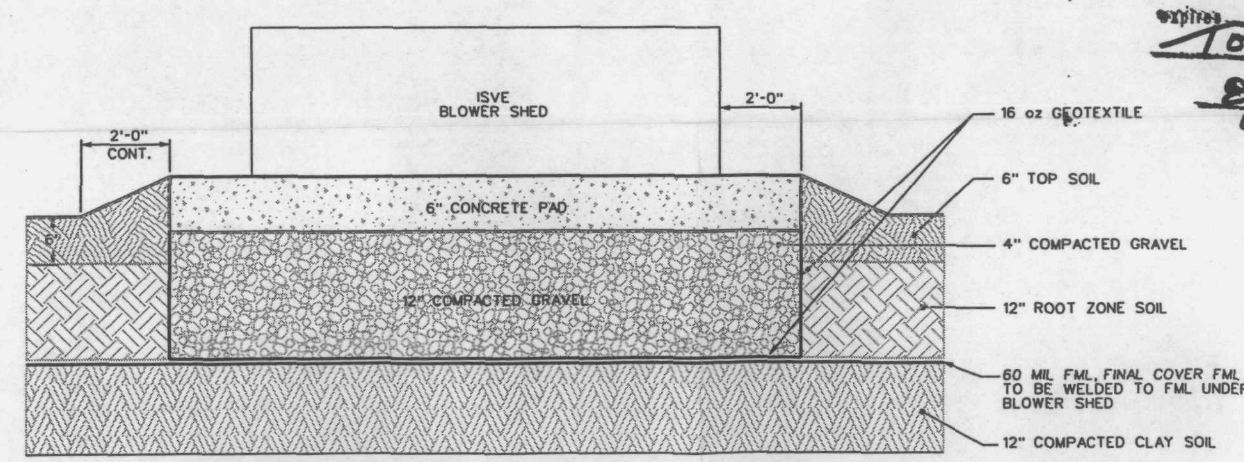
4 | C-12

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER
expires 1/31/00
signature
date 8/20/99



OFF-SITE CONTAINMENT AREA/K-P AREA VAPOR EXTRACTION WELL HEAD
NOT TO SCALE

3 | C-5 | C-6



NOTE:
ENTIRE COVER THICKNESS TO BE BUILT UNDER BLOWER SHED AS PART OF INTERIM COVER CONSTRUCTION. FINAL COVER TO BE TIED INTO INTERIM COVER AT BLOWER SHED LOCATION DURING FINAL COVER CONSTRUCTION.

OFF-SITE CONTAINMENT AREA BLOWER SHED
NOT TO SCALE

5 | C-5 | C-7

Job No: MW Job # File: J:/1252/042/28/revised/detail/cd103042.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION

SCALE: NONE

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED TLH
DRAWN RBA
CHECKED TAB

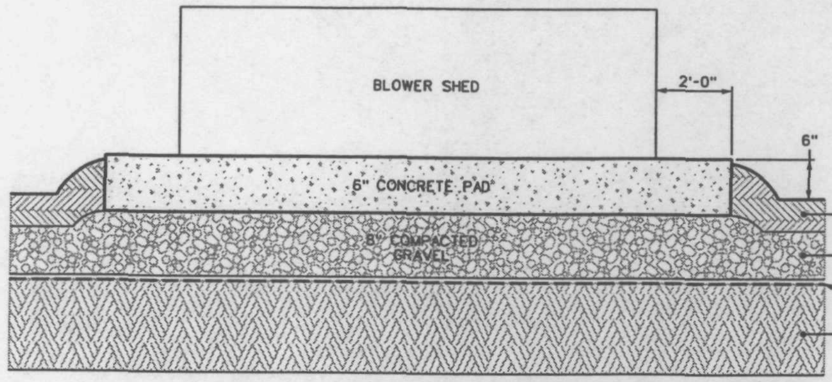
SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) — IN-19600482 LICENSE NO. — DATE
(COMPANY OFFICER) — LICENSE NO. — DATE

MONTGOMERY WATSON
Chicago, Illinois

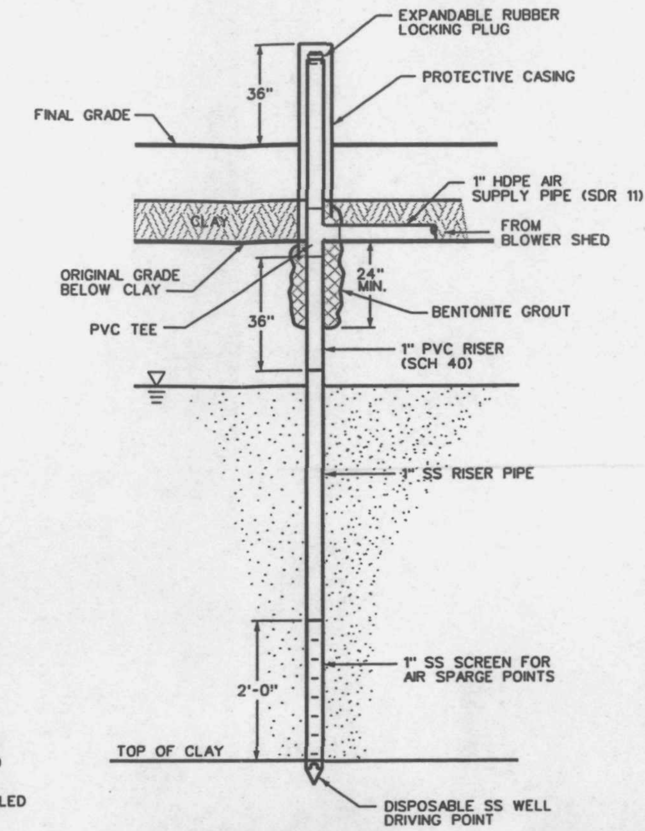
ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
ISVE SYSTEM DETAILS

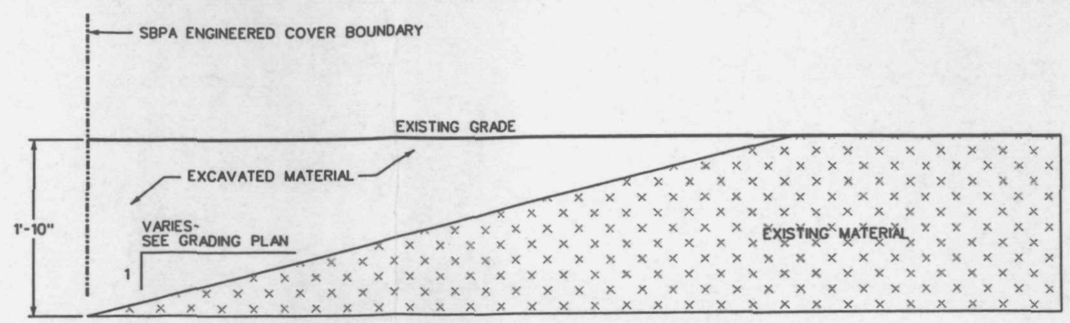
SHEET C-17



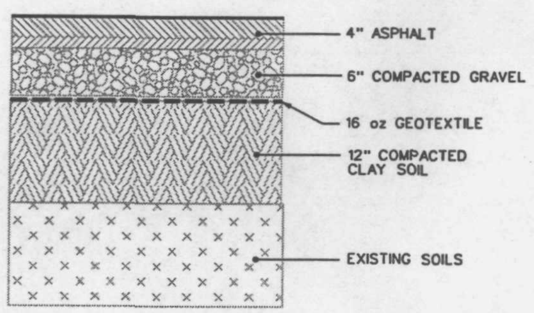
STILL BOTTOMS POND AREA BLOWER SHED
NOT TO SCALE
2 / C-12



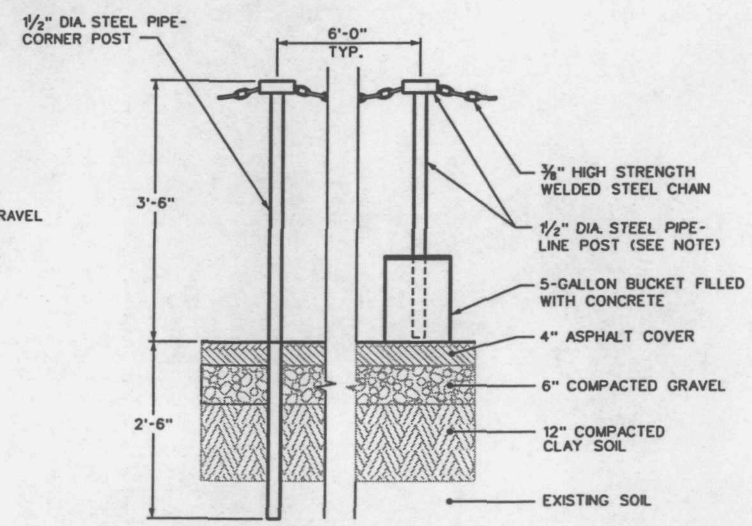
AIR SPARGE POINT DETAIL
NOT TO SCALE
3 / C-5 / C-12



TYPICAL CUT TRANSITION ALONG SBPA ENGINEERED COVER BOUNDARY
NOT TO SCALE
A / C-10

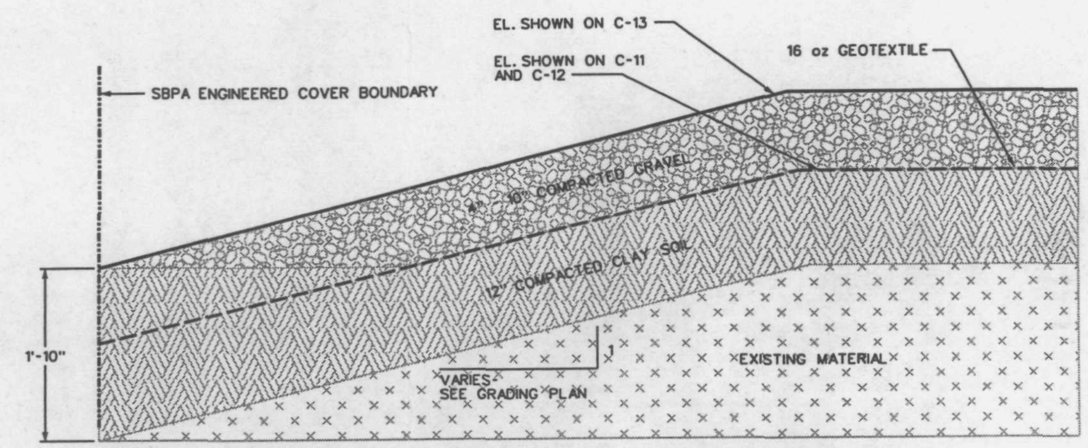


TYPICAL COVER STILL BOTTOMS POND AREA
NOT TO SCALE
5 / C-14



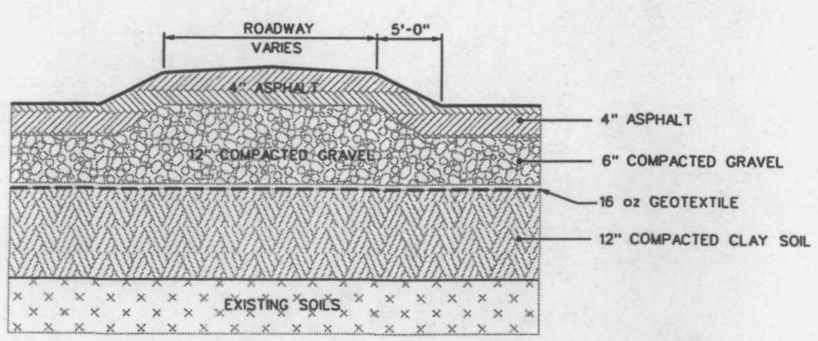
NOTE:
EVERY 10th LINE POST TO BE CONSTRUCTED SIMILAR TO CORNER POST.

SBPA CHAIN-LINK FENCE
NOT TO SCALE
4 / C-14

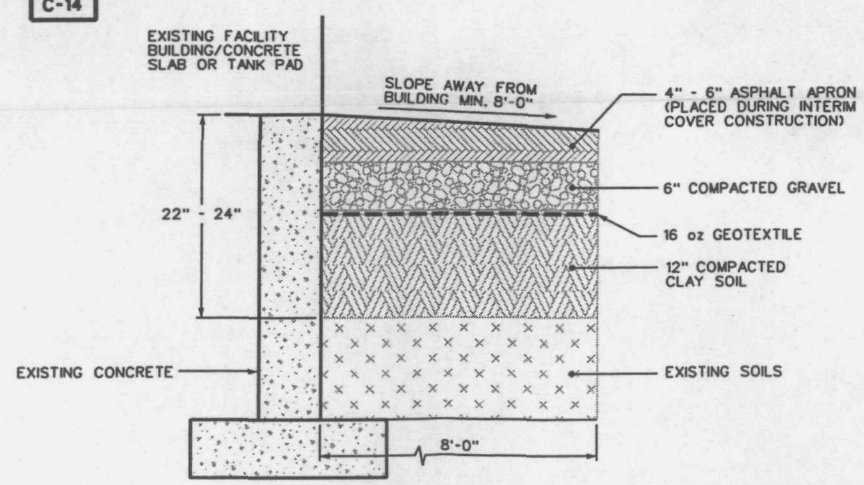


NOTE:
INTERIM COVER CLAY AND GRAVEL LAYERS TO BE GRADED SUCH THAT SURFACE WATER DRAINS AWAY FROM COVER, AND DOES NOT ACCUMULATE AT COVER BOUNDARY.

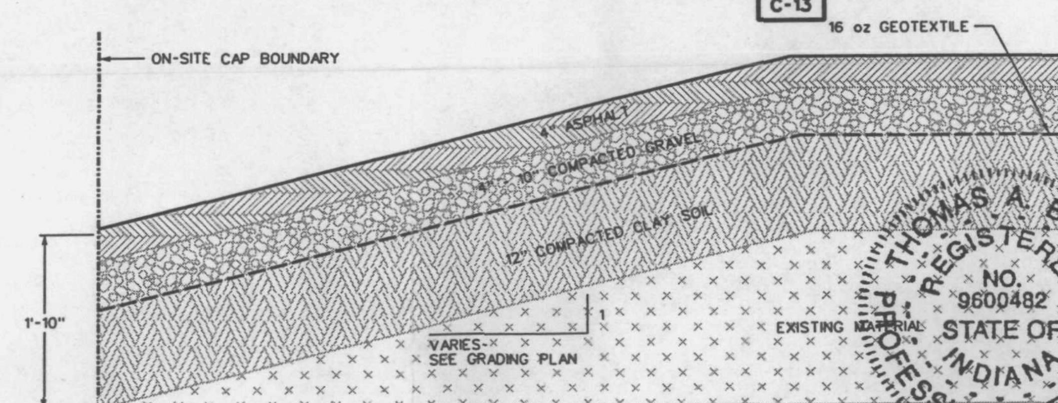
INTERIM SBPA ENGINEERED COVER TIE-IN DETAIL
NOT TO SCALE
B / C-11 / C-12 / C-13



STILL BOTTOMS POND AREA ACCESS ROAD
NOT TO SCALE
D / C-14



STILL BOTTOMS POND AREA INTERIM AND FINAL SBPA BUILDING TIE-IN
NOT TO SCALE
1 / C-11 / C-12 / C-13



NOTE:
GRAVEL LAYER FROM INTERIM COVER TO BE REGRADED AT COVER BOUNDARY TO A 6" THICKNESS PRIOR TO ASPHALT PLACEMENT.

FINAL SBPA ENGINEERED COVER TIE-IN DETAIL
NOT TO SCALE
C / C-14

THOMAS A. BLAIR REGISTERED PROFESSIONAL ENGINEER NO. 9600482 STATE OF INDIANA
expires 7/31/00
signature
8/20/99
date

Plot Date: $$$$date$$$$ $$time$$
File: J:/1252/042/28/revised/detail/cd105042.dgn
Job No: MW Job #

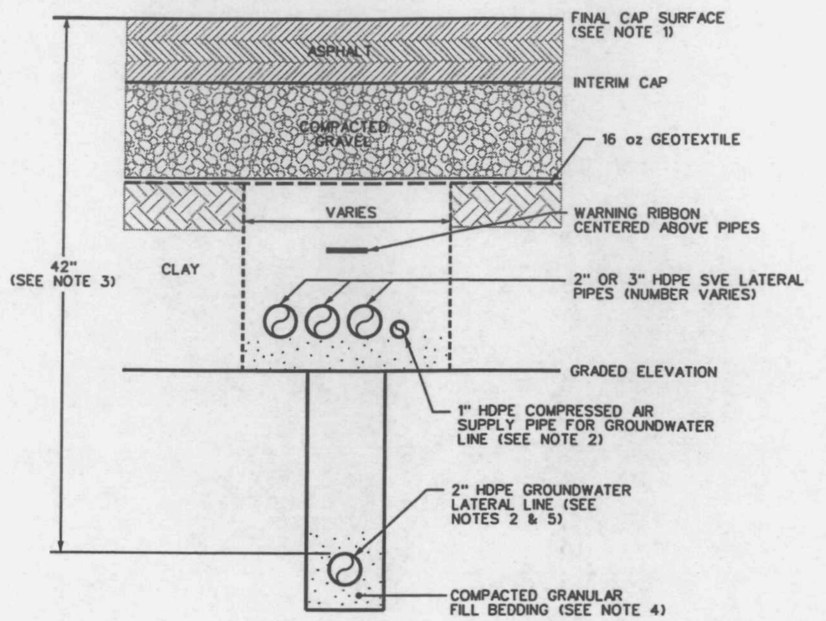
REV	DATE	BY	DESCRIPTION	SCALE	WARNING	DESIGNED / DRAWN / CHECKED	SUBMITTED BY			
				NONE	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED BPG/TAB; DRAWN RBA; CHECKED TAB	TOM BLAIR (PROJECT MANAGER) / (COMPANY OFFICER)	IN-19600482 LICENSE NO. / LICENSE NO.	DATE / DATE	

MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
SBPA COVER SECTIONS AND DETAILS

SHEET C-18



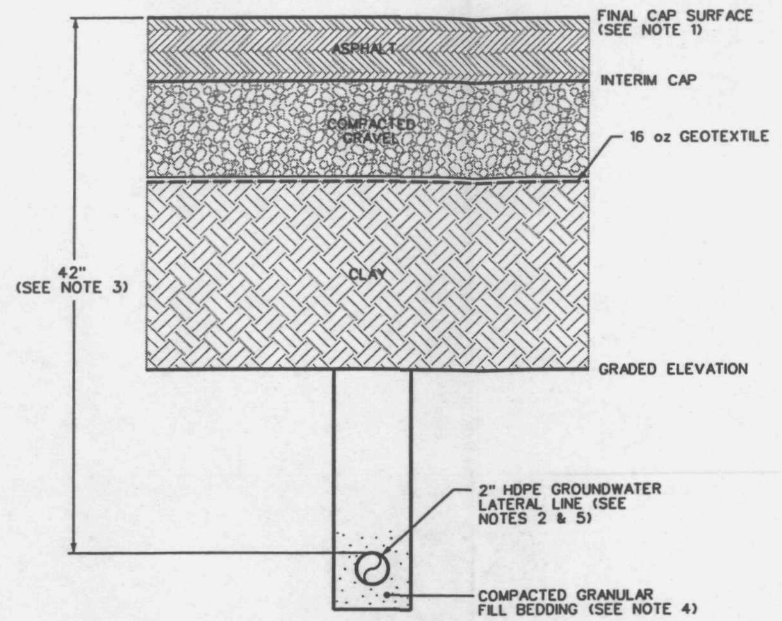
NOTES:

1. ON-SITE CAP SECTION IS SHOWN. SEE SHEET FOR DETAILS OF OFF-SITE CAP SECTION.
2. GROUNDWATER CONVEYANCE PIPE AND COMPRESSED AIR SUPPLY MAY NOT BE APPLICABLE TO ALL WELL FIELD TRENCHES (e.g. OFF-SITE CONTAINMENT AREA).
3. ALL PIPES CONVEYING GROUNDWATER OR CONDENSATE MUST HAVE A FINAL MINIMUM BURIED DEPTH OF 42".
4. A MINIMUM OF 2" COMPACTED GRANULAR FILL BEDDING SHOULD EXIST BETWEEN THE PIPES AND THE BOTTOM AND SIDES OF TRENCH
5. GROUNDWATER LATERAL LINE BELOW SVE LATERAL LINES FOR WELLS SVE-63, SVE-64 AND SVE-65.

TYPICAL ISVE WELL FIELD TRENCH CROSS SECTION

NOT TO SCALE

A / C-5 / C-6 / C-12



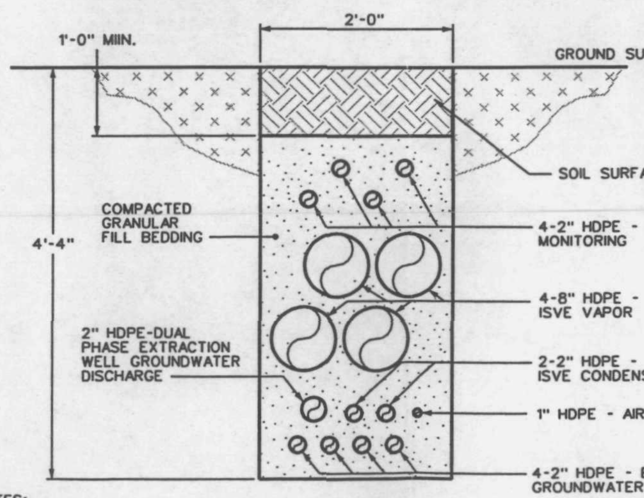
NOTES:

1. ON-SITE CAP SECTION IS SHOWN. SEE SHEET C-16 FOR DETAILS OF OFF-SITE CAP SECTION.
2. GROUNDWATER CONVEYANCE PIPE AND COMPRESSED AIR SUPPLY MAY NOT BE APPLICABLE TO ALL WELL FIELD TRENCHES (e.g. OFF-SITE CONTAINMENT AREA).
3. ALL PIPES CONVEYING GROUNDWATER OR CONDENSATE MUST HAVE A FINAL MINIMUM BURIED DEPTH OF 42".
4. A MINIMUM OF 2" COMPACTED GRANULAR FILL BEDDING SHOULD EXIST BETWEEN THE PIPES AND THE BOTTOM AND SIDES OF TRENCH
5. GROUNDWATER LATERAL LINE BELOW SVE LATERAL LINES FOR WELLS SVE-63, SVE-64 AND SVE-65.

TYPICAL PERIMETER GROUNDWATER CONVEYANCE TRENCH SECTION

NOT TO SCALE

B / C-10



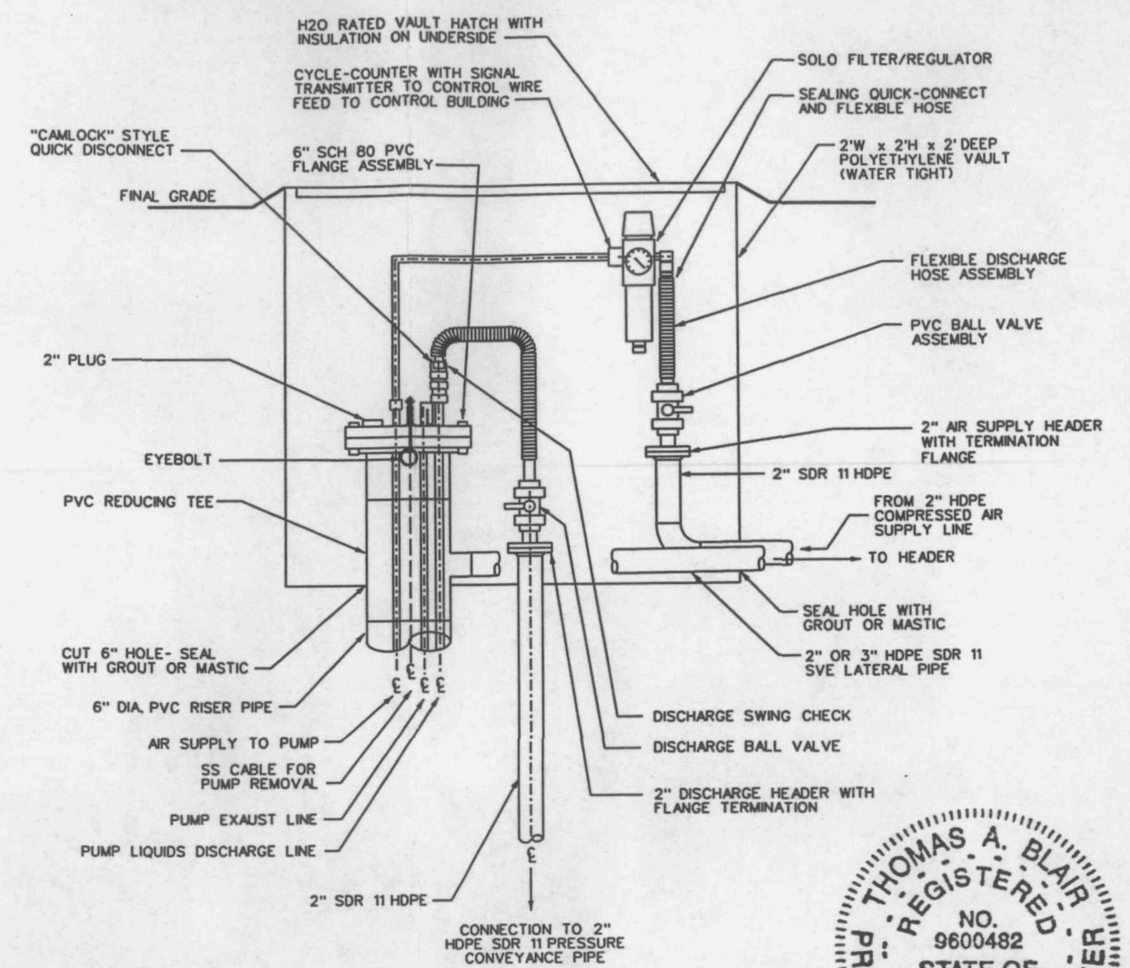
NOTES:

1. MAINTAIN 2" CLEARANCE AROUND ALL PIPES.
2. ALL PIPES CONVEYING GROUNDWATER OR CONDENSATE MUST HAVE A FINAL MINIMUM BURIED DEPTH OF 42". TO THE TOP OF THE PIPE.

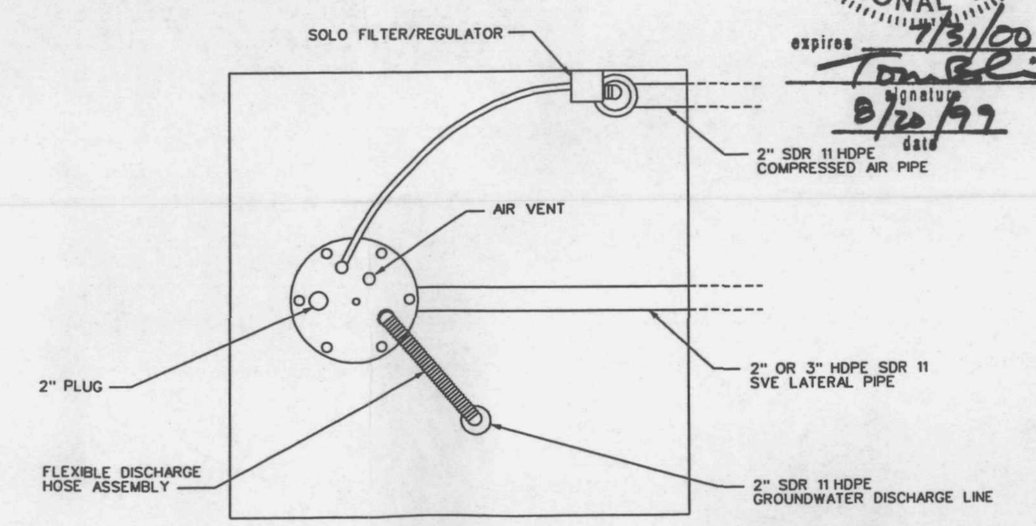
TYPICAL CONVEYANCE TRENCH TO GWTP

NOT TO SCALE

E / C-2 / C-5 / C-12



SECTION



PLAN

ON-SITE DUAL EXTRACTION WELL HEAD/ VAULT FINAL CONSTRUCTION

NOT TO SCALE

3 / C-12

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00

Tom Blair
signature

8/20/99
date

Plot Date: $$$$date$$$$ $$time$$

Job No: MW Job # File: J:/1252/042/28/revised/detail/cd10142.dgn

REV	DATE	BY	DESCRIPTION	SCALE	WARNING					
				NONE	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED RAA/TLH DRAWN RBA CHECKED RBA	SUBMITTED BY TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE (COMPANY OFFICER) LICENSE NO. DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN ISVE SYSTEM SECTIONS

SHEET C-19

KAPICA-PAZMEY AREA WELL SCHEDULE

WELL NO.	NORTHING	EASTING	HEAD DETAIL	WELL DIA. (in)	WELL DEPTH. (ft)	SCREEN LENGTH(ft)
SVE-1	5755.5	5063.7	stick-up	4	20	15
SVE-2	5781.0	5099.7	stick-up	4	20	15
SVE-3	5800.5	5140.3	stick-up	4	20	15
SVE-4	5762.1	5148.3	stick-up	4	20	15
SVE-5	5714.2	5073.2	stick-up	4	20	15
SVE-6	5730.4	5120.0	stick-up	4	20	15
SVE-7	5721.6	5158.6	stick-up	4	20	15
SVE-8	5743.6	5201.2	stick-up	4	20	15
SVE-9	5755.5	5241.9	stick-up	4	25	15
SVE-10	5797.8	5292.7	stick-up	4	25	15
SVE-11	5793.2	5242.8	stick-up	4	25	15
SVE-12	5785.0	5180.7	stick-up	4	20	15

OFF-SITE CONTAINMENT AREA WELL SCHEDULE

WELL NO.	NORTHING	EASTING	HEAD DETAIL	WELL DIA. (in)	WELL DEPTH. (ft)	SCREEN LENGTH(ft)
SVE-13	6065.8	5200.7	stick-up	4	20	10
SVE-14	6070.6	5238.8	stick-up	4	20	10
SVE-15	6065.5	5200.7	stick-up	4	20	15
SVE-16	6121.1	5210.5	stick-up	4	20	15
SVE-17	6164.7	5169.7	stick-up	4	20	15
SVE-18	6196.7	5219.5	stick-up	4	20	10
SVE-19	6225.1	5170.2	stick-up	4	20	15
SVE-20	6263.7	5172.8	stick-up	4	20	15
SVE-21	6291.7	5204.3	stick-up	4	20	15
SVE-22	6115.5	5277.4	stick-up	4	20	10
SVE-23	6155.0	5250.5	stick-up	4	20	10
SVE-24	6160.1	5291.7	stick-up	4	20	10
SVE-25	6204.4	5268.5	stick-up	4	20	15
SVE-26	6244.4	5226.6	stick-up	4	20	15
SVE-27	6255.6	5271.9	stick-up	4	20	10
SVE-28	6299.2	5259.2	stick-up	4	20	15
SVE-29	6295.8	5311.5	stick-up	4	20	15
SVE-30	6053.3	5296.8	stick-up	4	20	10
SVE-31	6004.0	5307.4	stick-up	4	20	15
SVE-32	6025.5	5341.7	stick-up	4	20	10
SVE-33	6067.5	5361.3	stick-up	4	20	10
SVE-34	6096.7	5323.2	stick-up	4	20	10
SVE-35	6119.3	5378.6	stick-up	4	20	10
SVE-36	6142.6	5336.9	stick-up	4	20	10
SVE-37	6166.8	5380.6	stick-up	4	20	10
SVE-38	6200.8	5332.3	stick-up	4	20	10
SVE-39	6208.9	5387.7	stick-up	4	20	15
SVE-40	6244.9	5321.2	stick-up	4	15	10
SVE-41	6247.5	5379.6	stick-up	4	20	15
SVE-42	6286.6	5354.7	stick-up	4	20	15

STILL BOTTOMS POND AREA WELL SCHEDULE

WELL NO.	NORTHING	EASTING	HEAD DETAIL	WELL DIA. (in)	APPROX. WELL DEPTH. (ft)	APPROX. SCREEN LENGTH(ft)
SVE-43	7014.5	5400.4	stick-up	6	20	15
SVE-44	6986.1	5392.2	stick-up	4	10	5
SVE-45	6967.9	5447.6	stick-up	6	21	15
SVE-46	7015.4	5481.5	flush	6	20	15
SVE-47	6959.0	5513.6	flush	6	21	15
SVE-48	6933.3	5555.7	flush	6	20	15
SVE-49	6917.7	5600.4	flush	6	21	15
SVE-50	6944.1	5359.2	stick-up	6	21	15
SVE-51	6930.6	5415.7	stick-up	4	10	5
SVE-52	6909.1	5455.3	stick-up	4	10	5
SVE-53	6896.7	5502.3	stick-up	4	10	5
SVE-54	6878.3	5548.3	stick-up	4	10	5
SVE-55	6853.9	5595.2	flush	6	20	15
SVE-56	6800.0	5623.3	stick-up	4	10	5
SVE-57	6792.8	5664.2	flush	6	20	15
SVE-58	6897.5	5320.6	stick-up	6	20	15
SVE-59	6908.2	5382.1	stick-up	4	10	5
SVE-60	6856.3	5404.6	stick-up	4	10	5
SVE-61	6872.3	5444.1	stick-up	6	22	15
SVE-62	6856.4	5480.8	stick-up	4	10	5
SVE-63	6810.0	5508.6	stick-up	6	22	15
SVE-64	6827.5	5540.6	stick-up	4	10	5
SVE-65	6772.5	5562.0	stick-up	6	22	15
SVE-66	6804.7	5590.0	stick-up	4	10	5
SVE-67	6770.0	5609.6	stick-up	4	10	5
SVE-68	6749.6	5657.5	stick-up	4	10	5
SVE-69	6740.3	5692.9	flush	6	20	15
SVE-70	6864.8	5348.1	stick-up	4	10	5
SVE-71	6823.8	5464.0	stick-up	4	10	5
SVE-72	6802.3	5421.3	stick-up	4	10	5
SVE-73	6736.7	5484.7	stick-up	4	10	5
SVE-74	6748.4	5523.0	stick-up	4	10	5
SVE-75	6722.1	5568.1	stick-up	4	10	5
SVE-76	6720.3	5618.6	stick-up	4	10	5
SVE-77	6668.0	5625.2	flush	6	20	15
SVE-78	6689.5	5675.0	flush	6	20	15
SVE-79	6797.2	5334.4	flush	6	20	15
SVE-80	6765.5	5363.3	flush	6	20	15
SVE-81	6751.0	5421.1	stick-up	4	10	5
SVE-82	6740.8	5389.9	flush	6	20	15
SVE-83	6728.9	5462.7	stick-up	4	10	5
SVE-84	6685.0	5445.9	flush	6	20	15
SVE-85	6704.2	5508.8	stick-up	4	10	5
SVE-86	6666.2	5503.5	flush	6	20	5
SVE-87	6670.4	5552.0	flush	6	20	15
SVE-88	6822.3	5445.1	stick-up	4	10	5

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00
Tom Blair
signature
8/20/99
date

REV	DATE	BY	DESCRIPTION

SCALE

WARNING
0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED
DRAWN RBA
CHECKED TAB

SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) — IN-19600482 LICENSE NO. — DATE
(COMPANY OFFICER) — LICENSE NO. — DATE

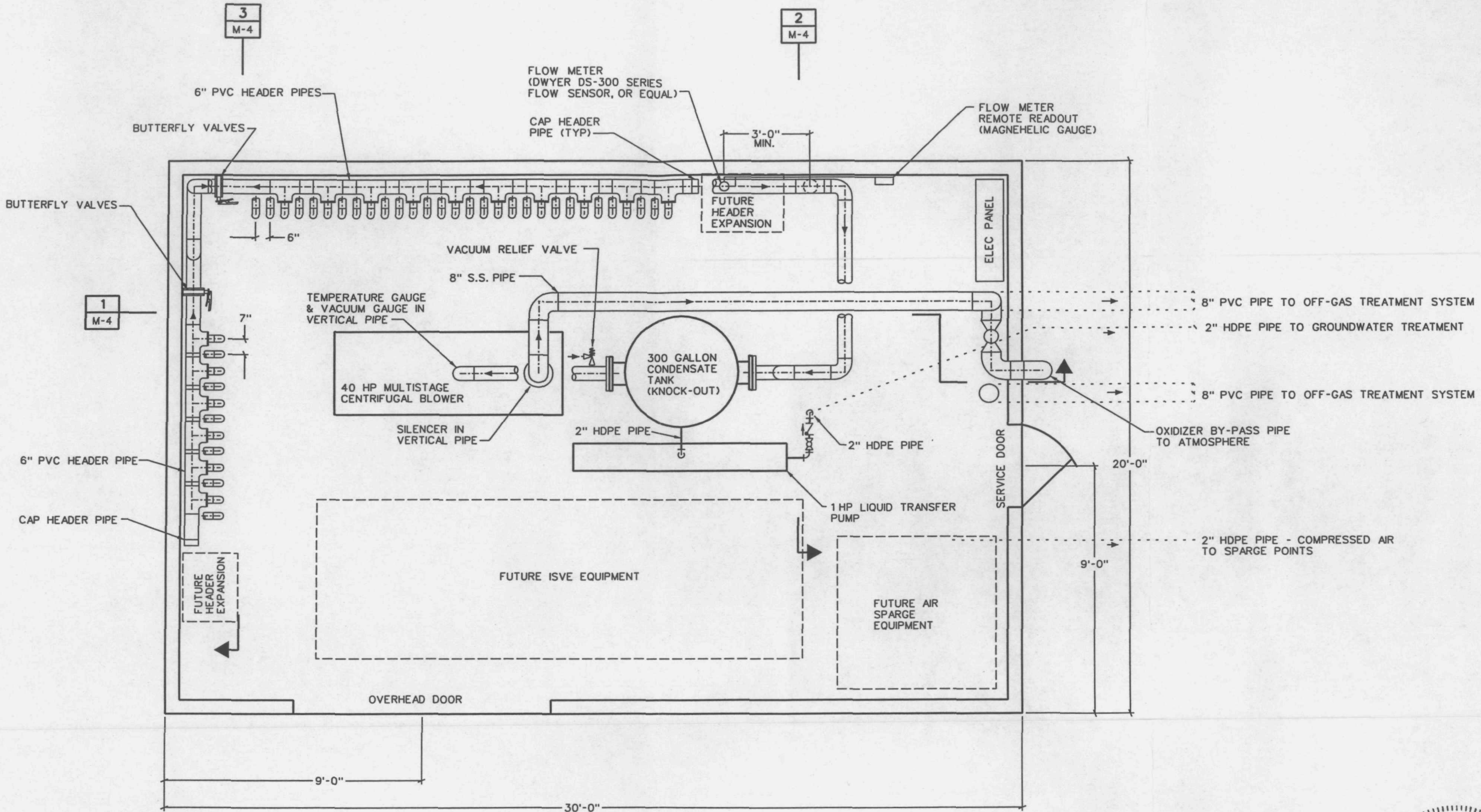
MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
ISVE WELL SCHEDULES

SHEET
C-20

Job No: MW Job • File: J:/1252/042/28/drawings/gen/gsch1042.dgn Plot Date: $$$$date$$$$ $$time$$



NOTES:

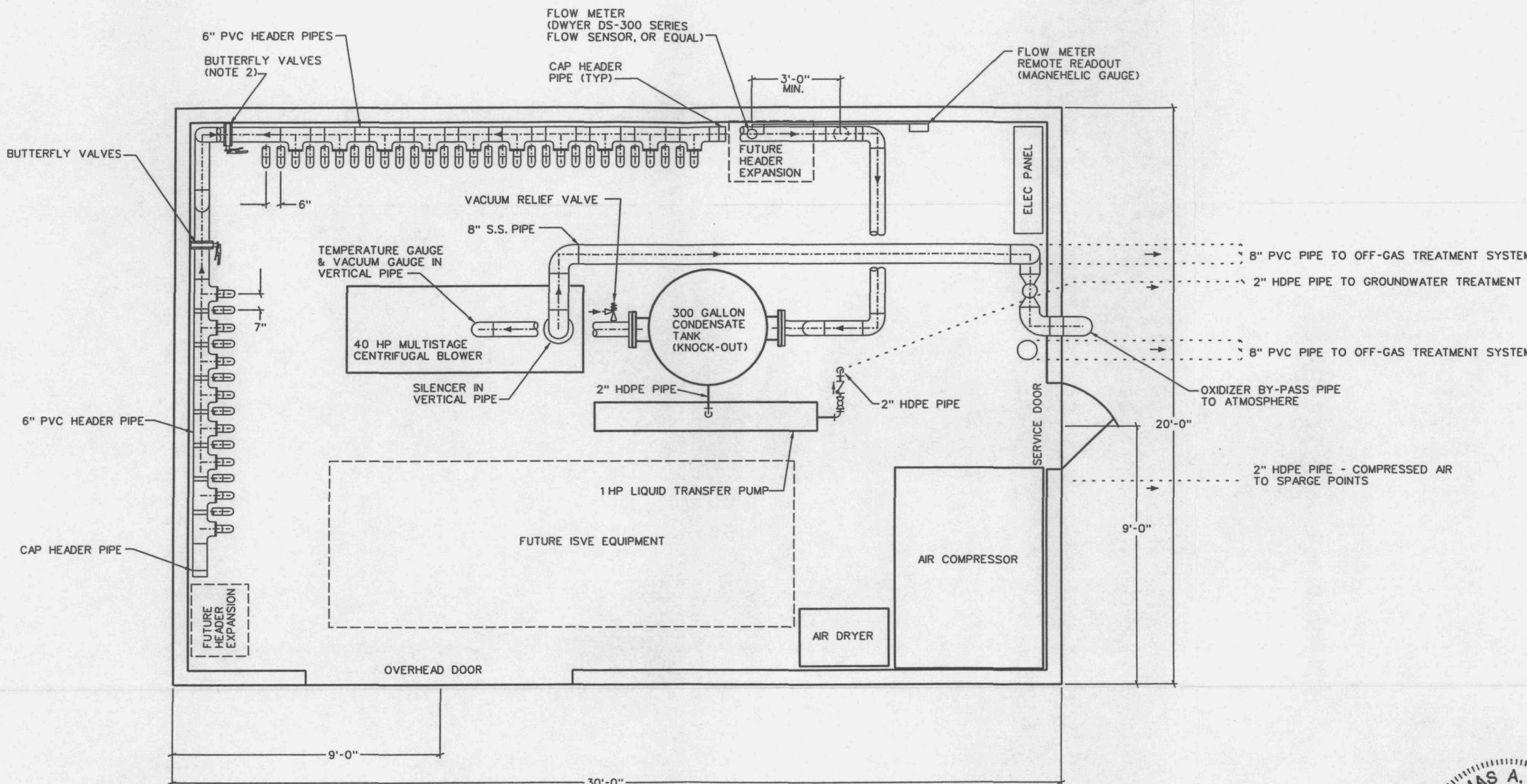
1. ALL PVC PIPE IS SCHEDULE 40.
2. PIPE SUPPORTS TO BE LOCATED AT ALL VALVES 6" DIAMETER AND LARGER. OTHER PIPE SUPPORT LOCATIONS TO BE DETERMINED BY ACTUAL EQUIPMENT SELECTION AND LOCATION. PIPE HANGERS SHALL BE CAPABLE OF SUPPORTING THE PIPE IN ALL CONDITIONS OF OPERATION, ALLOWING FREE EXPANSION AND CONTRACTION OF THE PIPING, AND PREVENTING EXCESSIVE STRESS ON EQUIPMENT.

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF
INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00
Tom Blair
signature
8/20/99
date

Job No: MW Job • File: J:/1252/042/28/drawings/detail/cdtm1042.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY						SHEET
				1"-2'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED K. LEWIS DRAWN J. DRISCOLL CHECKED M. BASEL	TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE (COMPANY OFFICER) LICENSE NO. DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN ISVE SYSTEM LAYOUT KAPICA-PAZMEY AREA AND OFF-SITE AREA BLOWER SHED			M-1



NOTES:

1. ALL PVC PIPE IS SCHEDULE 40.
2. BUTTERFLY VALVES MOUNTED OVER 6.0' HIGH TO BE CHAIN ACTIVATED, ALL OTHERS TO BE LEVER ACTIVATED.
3. PIPE SUPPORTS TO BE LOCATED AT ALL VALVES 6" DIAMETER AND LARGER. OTHER PIPE SUPPORT LOCATIONS TO BE DETERMINED BY ACTUAL EQUIPMENT SELECTION AND LOCATION. PIPE HANGERS SHALL BE CAPABLE OF SUPPORTING THE PIPE IN ALL CONDITIONS OF OPERATION, ALLOWING FREE EXPANSION AND CONTRACTION OF THE PIPING, AND PREVENTING EXCESSIVE STRESS ON EQUIPMENT.
4. ACTUAL PIPE & EQUIPMENT LAYOUT SUBJECT TO CHANGE BASED ON PHASED START-UP OF ISVE SYSTEM IN OFF-SITE AREA.

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER
expires 7/31/00
Tom Blair
signature
8/20/99
date

REV	DATE	BY	DESCRIPTION

SCALE 1"=2'-0"

WARNING 0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED K. LEWIS
DRAWN J. DRISCOLL
CHECKED M. BASEL

SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE
(COMPANY OFFICER) LICENSE NO. DATE

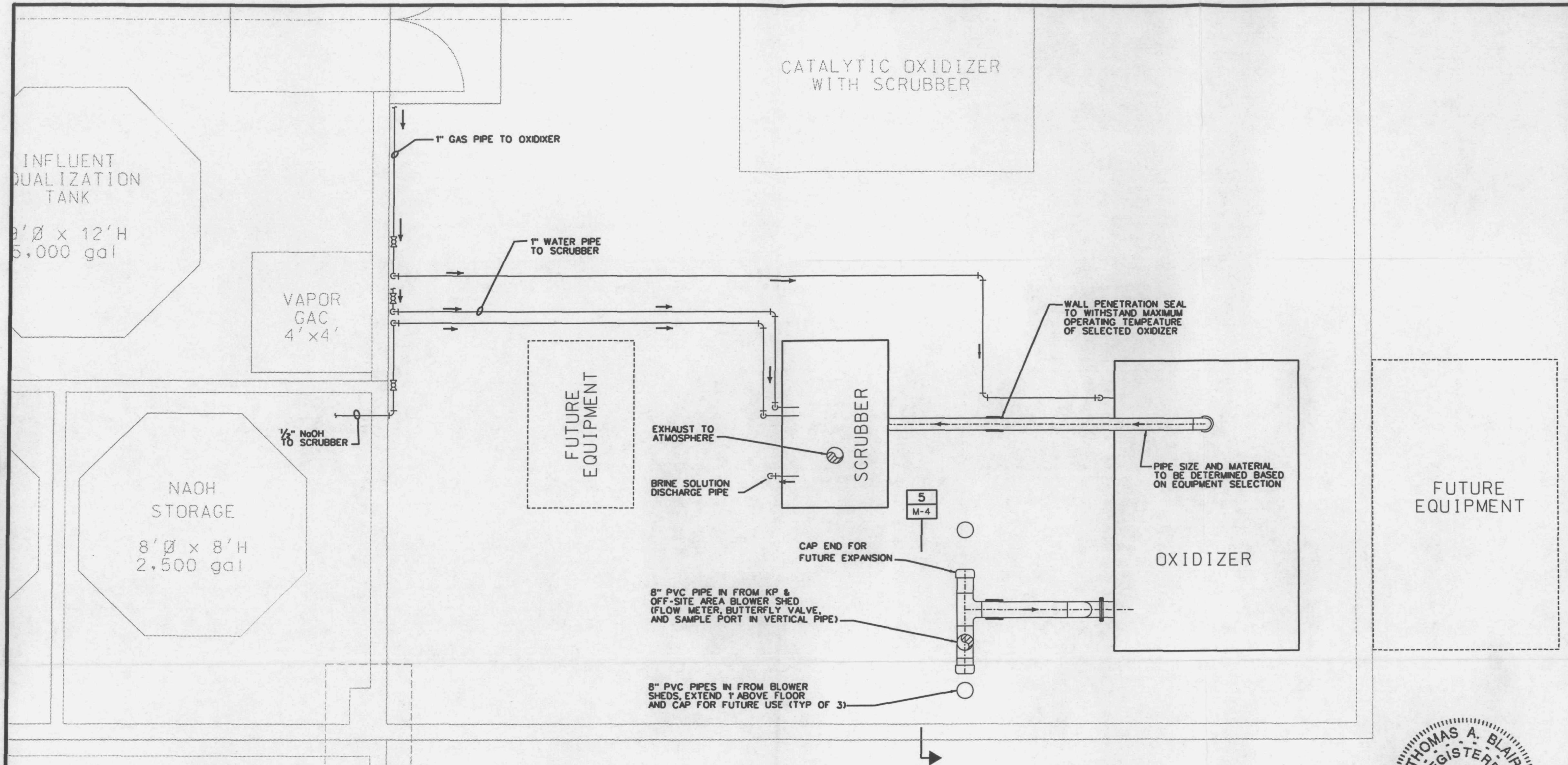
MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
ISVE SYSTEM LAYOUT
STILL BOTTOMS POND AREA
BLOWER SHED

SHEET M-2

Job No: MW Job # File: J:/1252/042/28/drawings/detail/cdlm2042.dgn Plot Date: $$$$date$$$$ $$time$$



000 GAL
ROXIDE STORAGE TANK

NOTES:

1. ALL PVC PIPE IS SCHEDULE 40.
2. BUTTERFLY VALVES MOUNTED OVER 6.0' HIGH TO BE CHAIN ACTIVATED, ALL OTHERS TO BE LEVER ACTIVATED.
3. PIPE SUPPORTS TO BE LOCATED AT ALL VALVES 6" DIAMETER AND LARGER. OTHER PIPE SUPPORT LOCATIONS TO BE DETERMINED BY ACTUAL EQUIPMENT SELECTION AND LOCATION. PIPE HANGERS SHALL BE CAPABLE OF SUPPORTING THE PIPE IN ALL CONDITIONS OF OPERATION, ALLOWING FREE EXPANSION AND CONTRACTION OF THE PIPING, AND PREVENTING EXCESSIVE STRESS ON EQUIPMENT.
4. FINAL EQUIPMENT CONFIGURATION TO BE DETERMINED BASED ON ACTUAL EQUIPMENT SELECTED.

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00
Tom Blair
signature
8/20/99
date

Job No: MW Job # File: Jr/1252/042/28/drawings/detail/cdlm3042.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION

SCALE: 1"=2'-0"

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED: K. LEWIS
DRAWN: J. DRISCOLL
CHECKED: M. BASEL

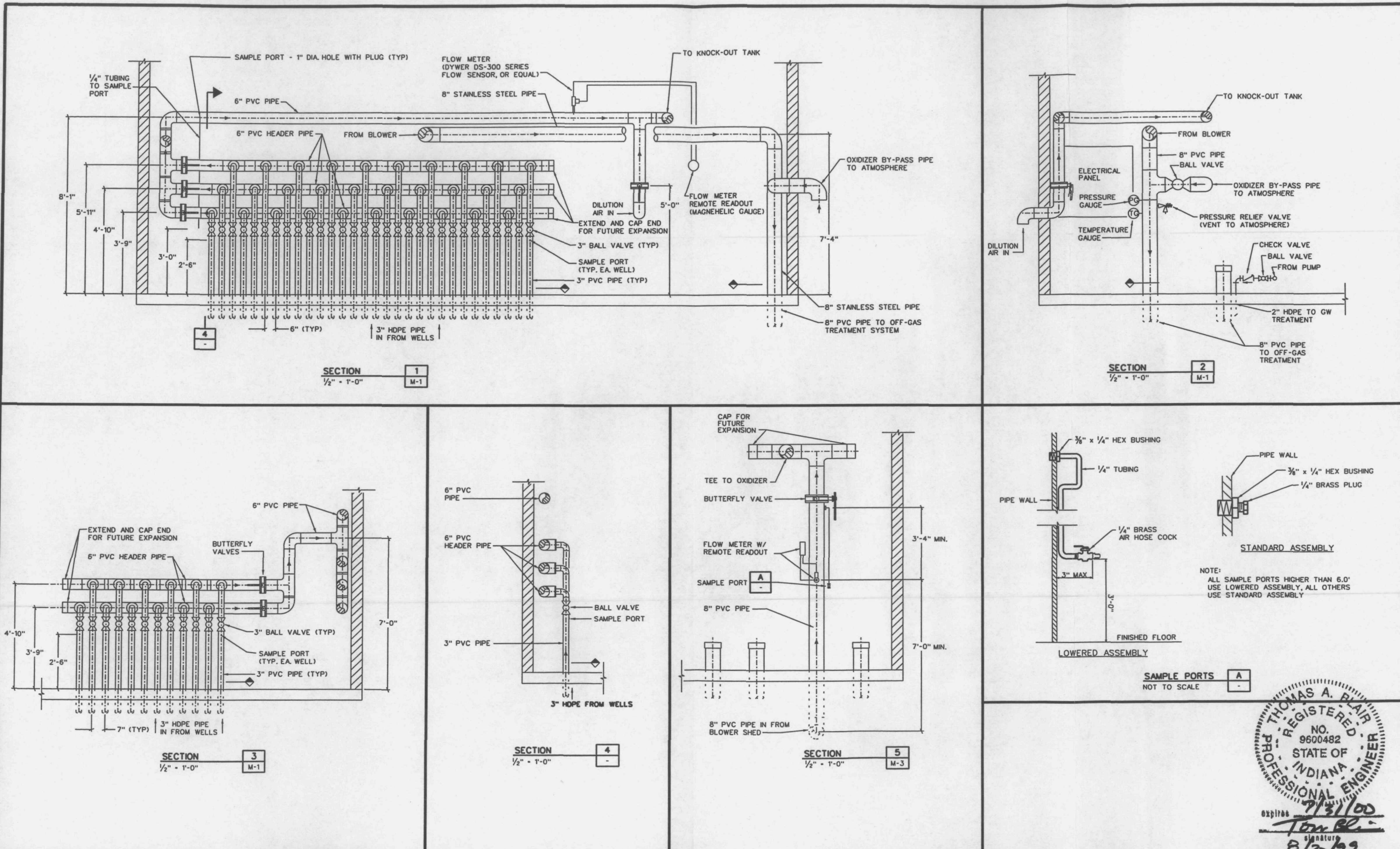
SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) — IN-19600482 LICENSE NO. — DATE
(COMPANY OFFICER) — LICENSE NO. — DATE

MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
OFF-GAS TREATMENT SYSTEM LAYOUT

SHEET M-3



REV	DATE	BY	DESCRIPTION

SCALE: NONE

WARNING 0 1/2 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED K. LEWIS
DRAWN J. DRISCOLL
CHECKED M. BASEL

SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) — IN-19600482 LICENSE NO. — DATE
(COMPANY OFFICER) — LICENSE NO. — DATE

MONTGOMERY WATSON
Chicago, Illinois

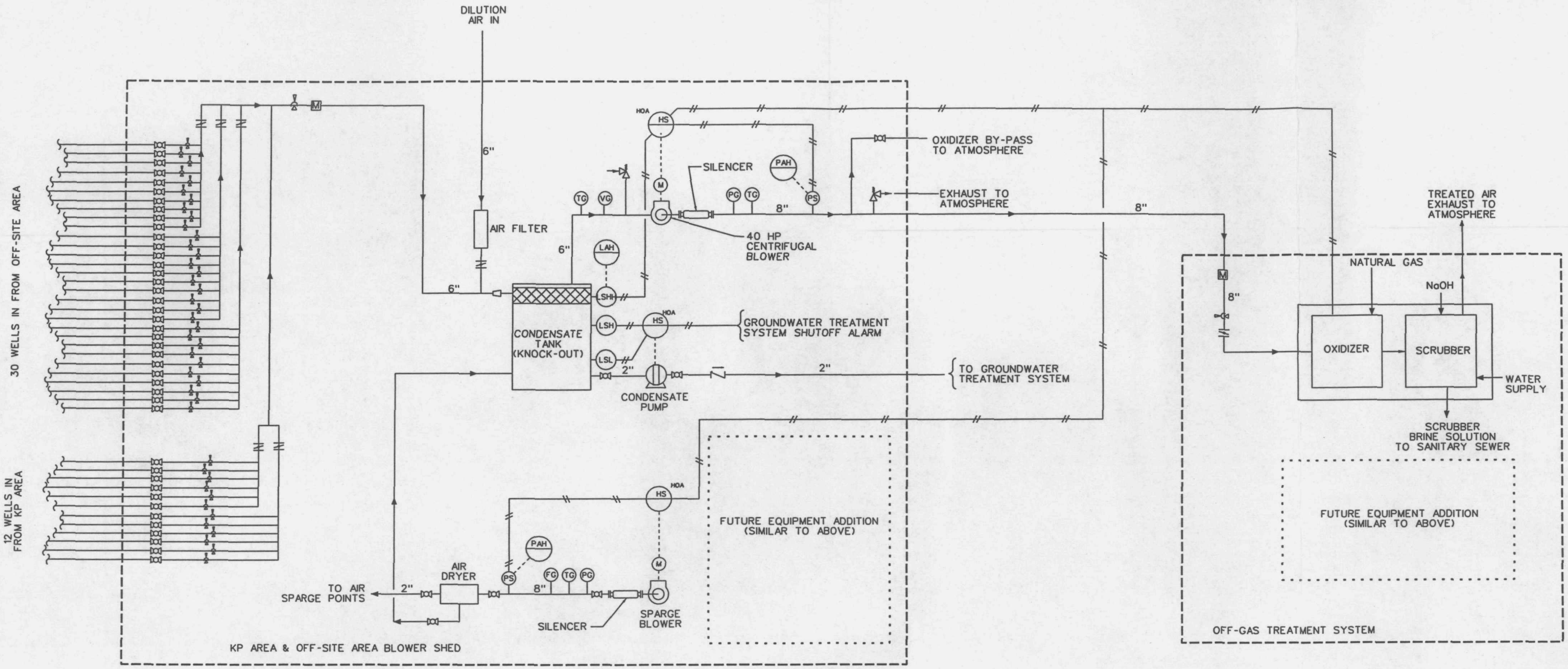
ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN

ISVE SYSTEM AND OFF-GAS TREATMENT SECTIONS AND DETAILS

SHEET M-4

Job No: MW Job # File: Jr/1252/042/28/drawings/cdtm4042.dgn Plot Date: $$$$date$$$$ $$time$$



LEGEND:

HS	HAND SWITCH
HOA	HAND-OFF-AUTO
LAH	LEVEL ALARM HIGH
LSHH	LEVEL SWITCH HIGH HIGH
LSH	LEVEL SWITCH HIGH
LSL	LEVEL SWITCH LOW
PAH	PRESSURE ALARM HIGH

SILENCER
BLOWER
AIR OPERATED PUMP
FIELD MOUNTED INSTRUMENT
CONTROL PANEL MOUNTED INSTRUMENT
(M) MOTOR
(PG) PRESSURE GAUGE
(TG) TEMPERATURE GAUGE
(VG) VACUUM GAUGE

(FG) FLOW GAUGE (MAGNEHELIC W/PITOT TUBE)
(PS) PRESSURE SWITCH
[M] METER
REDUCER
BUTTERFLY VALVE
BALL VALVE
CHECK VALVE
PRESSURE RELIEF VALVE
VACUUM RELIEF VALVE
SAMPLE PORT

FUTURE EQUIPMENT
LOGIC LINK
MECHANICAL/PROCESS LINK
ELECTRICAL LINK

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER
expires 7/31/00
signature
8/20/99
date

NOTE:
STILL BOTTOMS AREA BLOWER BUILDING CONFIGURATION TO BE SIMILAR TO KP AREA & OFF-SITE AREA BLOWER BUILDING

REV	DATE	BY	DESCRIPTION

SCALE: NONE

WARNING
0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED K. LEWIS
DRAWN J. DRISCOLL
CHECKED M. BASEL

SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE
(COMPANY OFFICER) LICENSE NO. DATE

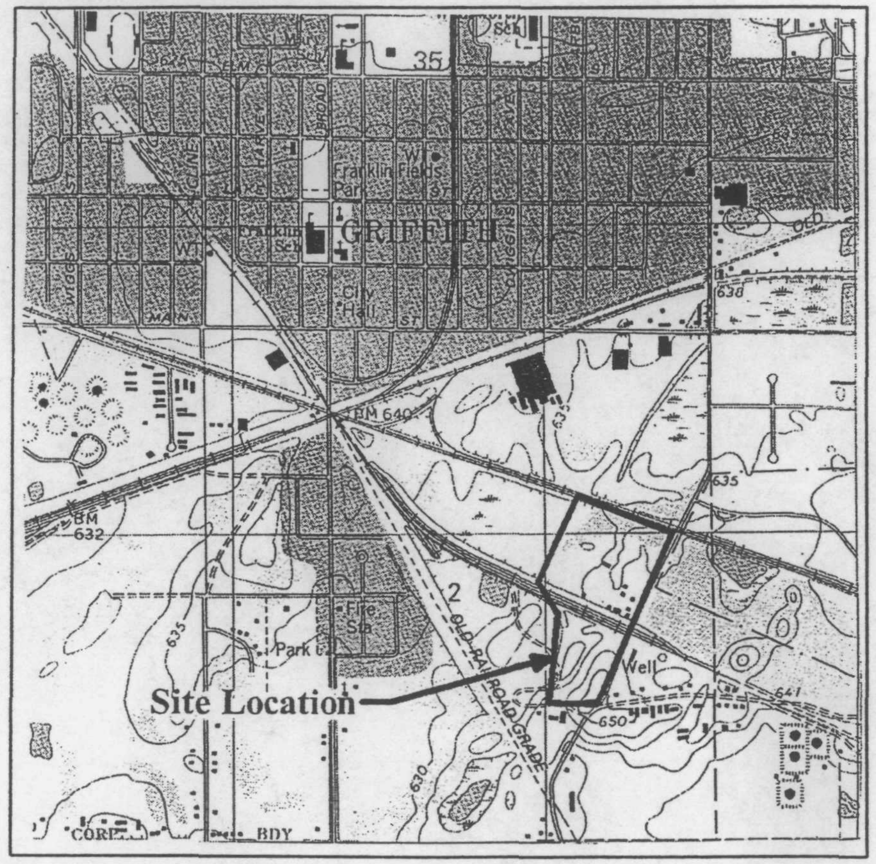
MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
ISVE SYSTEM
PROCESS AND INSTRUMENTATION DIAGRAM

SHEET I-1

Job No: MW Job • File: J:/1252/042/28/drawings/detail/pid01042.dgn Plot Date: $$$$date$$$$ $$time$$



Sheet Index

ACS RD/RA Group

100% RD Drawings for the Design/Build Construction of

Final Remedial Action

American Chemical Service Superfund Site
August 1999

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00

8/20/99
date

MONTGOMERY WATSON
Chicago, Illinois

GENERAL STANDARD SYMBOLS SHEET

- ASPHALT CEMENT PAVING
- CONCRETE PAVING
- GRAVEL PAVING
- COMPACTED CLAY (IN SECTION)
- ROOT ZONE SOIL OR GENERAL FILL (IN SECTION)
- BENTONITE SLURRY OR CHIPS
- SAND
- SAND OR FILTER PACK
- TOPSOIL
- RIP-RAP
- EXISTING SOILS
- GRAVEL/DRAINROCK/AGGREGATE BASE
- EARTH
- FLOW LINE
- SOIL BORING
- MONITORING WELL
- BENCH MARK
- PIPE IN SECTION
- CL OR ℄ — CENTERLINE
- PL OR ℘ — PROPERTY LINE
- R/W — RIGHT-OF-WAY LINE
- ESMT — EASEMENT LINE
- TEMP ESMT — TEMPORARY EASEMENT LINE
- G — UTILITIES
- G — GAS LINE (SIZE NOTED WHERE LARGER THAN 3-INCH)
- HP GAS — HIGH PRESSURE GAS
- 2" W — WATER LINE (SIZE INDICATED)
- TEL — UNDERGROUND TELEPHONE
- HVAC — HIGH VOLTAGE AC POWER LINE
- 27" SS — SANITARY SEWER (SIZE INDICATED)
- OHW — OVERHEAD WIRES
- 27" SD — STORM DRAIN (SIZE INDICATED)
- FOC — FIBER OPTIC CABLE
- COMM — COMMUNICATIONS CABLE
- PP — PROCESS PIPING
- FENCE (NEW)
- FENCE (EXISTING)
- WATER COURSE
- TRAIL OF DIRT ROAD
- 125 — MAJOR CONTOUR LINE (NEW)
- 125 — MAJOR CONTOUR LINE (EXISTING)
- VEGETATION

- N 6,512.6 / E 5,256.3 / EL. 640.0 — FINISHED ELEVATION
- 638.3x — EXISTING ELEVATION
- 12x24 — DUCT (FIRST DIMENSION DUCT SIDE SHOWN, SECOND DIMENSION DUCT SIDE NOT SHOWN)
- 24x12 — SUPPLY OR OUTSIDE AIR DUCT (FIRST DIMENSION, DUCT WIDTH)
- 24x12 — EXHAUST OR RETURN AIR DUCT (FIRST DIMENSION, DUCT WIDTH)
- SIZE / CFM — CEILING SUPPLY DIFFUSER (SIZE IN INCHES)
- SIZE / CFM — CEILING RETURN OR EXHAUST AIR GRILLE OR REGISTER (SIZE IN INCHES, WIDTH X HEIGHT)
- SIZE / CFM — EXHAUST OR RETURN AIR GRILLE OR R REGISTER (SIZE IN INCHES, WIDTH X HEIGHT)
- SIZE / CFM — SUPPLY GRILLE OR REGISTER (SIZE IN INCHES, WIDTH X HEIGHT)
- AIR TURNING VANES IN DUCT
- DD — DEFLECTING DAMPER
- FHC — FIRE HOSE CABINET
- FE — FIRE EXTINGUISHER
- UNIT HEATER
- BALL VALVE
- DIAPHRAGM VALVE
- CHECK VALVE
- PRESSURE REGULATING VALVE
- BACK-PRESSURE VALVE
- M / P — MOTOR OPERATOR FOR VALVES (M - ELECTRIC, P - PNEUMATIC)
- T — TEMPERATURE CONTROL VALVE
- S — SOLENOID VALVE
- MULTIPORT VALVE - 3 WAY
- MULTIPORT VALVE - 4 WAY
- FLOAT OPERATED VALVE
- NEEDLE VALVE
- PRESSURE RELIEF VALVE
- ANGLE VALVE
- HOSE BIBB (H/B)
- INJECTOR OR EDUCATOR
- AIR VACUUM AND AIR RELEASE ASSEMBLY
- PIPE ANCHOR

- LIGHT POLE
- PP — POWER POLE
- PIPELINE (CIVIL SHEETS) 24" DIA AND LARGER
- PIPELINE (CIVIL SHEETS) 12" DIA TO 20" DIA
- PIPELINE (CIVIL SHEETS) 10" DIA AND SMALLER
- ISOLATION VAULT & MAJOR BLOWOFF VAULT (IN PLAN)
- CATHODIC TEST STATION (IN PROFILE)
- CATHODIC TEST STATION (IN PLAN) TYPES:
  - CTS — CORROSION TEST STATION
  - CATS — CASING TEST STATION
  - IJTS — INSULATING JOINT TEST STATION
  - FPTS — FOREIGN PIPELINE TEST STATION
  - CSTS — CURRENT SPAN TEST STATION
- FH — FIRE HYDRANT
- MH — MANHOLE
- CB — CATCH BASIN
- PCOTG — PRESSURE CLEANOUT TO GRADE
- COTG / CO — CLEANOUT TO GRADE
- REDUCER OR INCREASER (PROVIDE SIZE)
- ETS — ELECTROLYSIS TEST STATION
- WCO — WALL CLEANOUT
- FCO — FLOOR CLEANOUT
- HUB DRAIN
- FLOOR DRAIN
- FLOOR SINK
- CHANGE IN PIPING MATERIAL
- BACKWATER VALVE
- BACKFLOW PREVENTER
- STOP GATE
- SLIDE GATE
- SLUICE GATE
- GATE VALVE, BURIED WITH VALVE BOX
- BUTTERFLY VALVE, BURIED WITH VALVE BOX
- ECCENTRIC PLUG VALVE, BURIED WITH VALVE BOX
- LUBRICATED PLUG VALVE, BURIED WITH VALVE BOX
- GATE VALVE
- BUTTERFLY VALVE
- ECCENTRIC PLUG VALVE

- LUBRICATED PLUG VALVE
- GLOBE VALVE
- G — PRESSURE GAUGE
- G — PRESSURE GAUGE WITH DIAPHRAGM SEAL
- S — PRESSURE SWITCH
- S — PRESSURE SWITCH WITH DIAPHRAGM SEAL
- FLANGED FITTING
- MECHANICAL-TYPE FITTING (GROOVED)
- SCREWED, WELDED, SOCKET-WELD, BELL AND SPIGOT OR HUBLESS FITTING
- SLEEVE TYPE COUPLING
- FLANGED ADAPTER - SET SCREW TYPE
- MECHANICAL TYPE COUPLING
- FLEXIBLE COUPLING
- UNION
- QUICK DISCONNECT COUPLER
- CAPPED END OR PLUGGED END
- BLIND FLANGE
- REDUCER OR INCREASER
- STRAINER
- DRAIN
- FLOW TUBE
- M M — MAGNETIC METER
- D M — DENSITY METER
- P M — PROPELLER METER
- ORIFICE PLATE AND FLANGES
- ROTAMETER
- T — CONDENSATE TRAP
- PIPE SUPPORT (IN PLAN)
- PULSATION DAMPENER
- EXPANSION CHAMBER WITH RUPTURE DISC
- RUPTURE DISC
- FG / X — FLOW SIGHT GLASS

SECTION AND DETAIL IDENTIFICATION

SECTION IDENTIFICATION

- A / 3S-5 — SECTION LETTER; SHEET ON WHICH SECTION IS SHOWN
- SECTION A / 3S-1 — SHEET ON WHICH SECTION IS CUT

DETAIL IDENTIFICATION

- 3 / 2M-3 — DETAIL NUMBER; SHEET ON WHICH DETAIL IS SHOWN
- DETAIL 3 / 2M-2 — SHEET ON WHICH DETAIL IS CALLED-OUT

DISCIPLINE SPECIFIC SYMBOLS ARE SHOWN ON THE DISCIPLINE GENERAL DRAWINGS.

FOR WELDING SYMBOLS USE AMERICAN WELDING SOCIETY STANDARD SYMBOLS.

REV 042898

REV	DATE	BY	DESCRIPTION	SCALE

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED ______ DRAWN ______ CHECKED ______

SUBMITTED BY: TOM BLAIR (PROJECT MANAGER) — IN-19600482 LICENSE NO. — DATE; (COMPANY OFFICER) — LICENSE NO. — DATE

MONTGOMERY WATSON, Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
GENERAL STANDARD SYMBOLS SHEET

SHEET G-2

Job No: MW Job # File: J:/1252/042/drawings/gen/gsym1042.dgn Plot Date: ####date#### ##time##

A	AIR
A/C	AIR CONDITIONING
AASHTO	AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AB	ANCHOR BOLT
ABAN	ABANDON
ABAND	ABANDONED
ABBR	ABBREVIATION
ABS	ABSOLUTE TEMPERATURE
AC	ACTIVATED CARBON / ASPHALTIC CONCRETE / ALTERNATING CURRENT
ACI	AMERICAN CONCRETE INTERNATIONAL
ACOUS	ACOUSTIC / ACOUSTICAL
ACP	ASBESTOS CEMENT PIPE / ASPHALTIC CONCRETE PAVEMENT
ADD	ADDITIONAL
ADH	ADHESIVE
ADJ	ADJUSTABLE
AER	AERATION
AFF	ABOVE FINISHED FLOOR
AISC	AMERICAN INSTITUTE OF STEEL CONSTRUCTION
ALT	ALTERNATE
ALUM	ALUMINUM
AMB	AMBIENT
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
API	AMERICAN PETROLEUM INSTITUTE
APPD	APPROVED
APPROX	APPROXIMATE
APPURTS	APPURTENANCES
ARCH	ARCHITECTURE
AREA	AMERICAN RAILWAY ENGINEERING ASSOCIATION
ASME	AMERICAN SOCIETY OF MECHANICAL ENGINEERS
ASPH	ASPHALT
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
AT	ACOUSTICAL TILE
ATM	ATMOSPHERE
AV/AR	AIR VACUUM AND AIR RELEASE VALVE
AVE	AVENUE
AWPA	AMERICAN WOOD PRESERVERS ASSOCIATION
AWS	AMERICAN WELDING SOCIETY
AWWA	AMERICAN WATER WORKS ASSOCIATION
B&S	BELL AND SPIGOT
B/W	BACK OF WALL / BACK OF WALK
BC	BEGIN CURVE/BOLT CIRCLE/BETWEEN CENTERS
BCR	BEGIN CURB RETURN
BD	BOARD
BDRY	BOUNDARY
BF	BLIND FLANGE / BOTTOM OF FOOTING
BFP	BACK FLOW PREVENTER
BHP	BRAKE HORSEPOWER
BLDG	BUILDING
BLK	BLACK / BLOCK
BLKG	BLOCKING
BLVD	BOULEVARD
BM	BEAM / BENCH MARK
BO	BLOW-OFF ASSEMBLY
BOD	BIOCHEMICAL OXYGEN DEMAND
BOP	BOTTOM OF PIPE
BOT	BOTTOM
BPV	BACK PRESSURE VALVE
BRK	BRICK / BREAK
BSMT	BASEMENT
BT	BOLT
BTU	BRITISH THERMAL UNIT
BV	BUTTERFLY VALVE
BVC	BEGIN VERTICAL CURVE
BWV	BACK WATER VALVE
C	CENTIGRADE / CHANNEL / CEMENT
C&G	CURB AND GUTTER
CAB	CABINET / CRUSHED AGGREGATE BASE
CAP	CAPACITY
CATS	CASING TEST STATION
CB	CATCH BASIN / CHALK BOARD / CURB
CC	CLOSED CIRCUIT TV / CENTER TO CENTER
CD	CEILING DIFFUSER
CEM	CEMENT
CF	CURB FACE OF CUBIC FOOT
CFH	CUBIC FEET PER HOUR
CFM	CUBIC FEET PER MINUTE
CFS	CUBIC FEET PER SECOND
CHEM	CHEMICAL
CHG	CHANGE
CHKD	CHECKERED
CI	CAST IRON
CIP	CAST IRON PIPE / CAST IN PLACE
CIPP	CAST IN PLACE PIPE
CJ	CONSTRUCTION JOINT
CL	CHLORINE GAS / CHLORINATOR / CENTERLINE
CLF	CHAIN LINK FENCE
CLG	CEILING
CLOS	CLOSET
CLR	CLEAR / CLEARANCE
CM	CENTIMETER
CMB	CRUSHED MISCELLANEOUS BASE
CMC	CEMENT MORTAR-COATED
CML	CEMENT MORTAR-LINED
CML&C	CEMENT LINED AND COATED
CMP	CORRUGATED METAL PIPE
CMU	CONCRETE MASONRY UNIT
CO	CLEANOUT
COL	COLUMN
COMP	COMPRESSOR
CONC	CONCRETE / CONCENTRIC
COND	CONDENSER / CONDENSATE
CONN	CONNECTION
CONST	CONSTRUCT / CONSTRUCTION
CONT	CONTINUED / CONTINUOUS
CONTR	CONTRACTOR
COORD	COORDINATE
COR	CORNER
COTG	CLEANOUT TO GRADE
CPLG	COUPLING
CPVC	CHLORINATED POLYVINYL CHLORIDE
CS	CAUSTIC SODA / CAST STEEL
CSP	CORRUGATED STEEL PIPE
CSTS	CURRENT SPAN TEST STATION
CT	CERAMIC TILE
CTR	CENTER
CTS	CORROSION TEST STATION
CTSK	COUNTERSUNK
CU	COPPER / CUBIC
CULV	CULVERT
CV	CHECK VALVE
CY	CUBIC YARD
CYL	CYLINDER
d	PENNY
DAD	DOUBLE ACTING DOOR
DAFT	DISSOLVED AIR FLOTATION THICKENER
DB	DIRECT BURY
DBL	DOUBLE
DC	DIRECT CURRENT
DEG	DEGREE
DET	DUCTILE IRON
DF	DRINKING FOUNTAIN / DOUGLAS FIR
DG	DOUBLE HUNG
DH	DOUBLE HUNG
DI	DUCTILE IRON
DIA	DIAMETER
DIAG	DIAGONAL
DIAPH	DIAPHRAGM
DIFF	DIFFUSER / DIFFERENTIAL
DIP	DUCTILE IRON PIPE
DIR	DIRECTION
DISCH	DISCHARGE
DISP	DISPENSER
DL	DEAD LOAD
DMH	DROP MANHOLE
DN	DOWN
DO	DISSOLVED OXYGEN / DITTO
DR	DOOR / DRAIN
DS	DRENCH SHOWER AND EYE WASH
DT	DRAIN TILE
DWG	DRAWING
DWLS	DOWELS
DWY	DRIVEWAY
E	EAST
E/O	EAST OF
EA	EACH
EB	EXPANSION BOLT OR ANCHOR
EC	END CURVE
ECC	ECCENTRIC
ECR	END CURB RETURN
EF	EACH FACE / EXHAUST FAN
EFF	EFFLUENT
EG	EXISTING GRADE / EDGE OF GUTTER / EXHAUST GRILLE
EGL	ENERGY GRADE LINE
EL	ELEVATION
ELEC	ELECTRICAL / ELECTRONIC
EN	EDGE NAILING
ENCL	ENCLOSURE
ENG	ENGINE
ENGR	ENGINEER
ENT	ENTRANCE
EP	EDGE OF PAVEMENT
EPT	ETHYLENE PROPYLENE
EQ	EQUAL
EQUIP	EQUIPMENT
ESMT	EASEMENT
ETB	EMULSION TREATED BASE
ETC	ET CETERA
EVAP	EVAPORATOR
EVC	END VERTICAL CURVE
EW	EACH WAY / EYE WASH
EX	EXISTING
EXC	EXCAVATION
EXH	EXHAUST
EX-HY	EXTRA HEAVY
EXIST	EXISTING
EXP	EXPANSION
EXT	EXTERIOR / EXTENSION
EXTR	EXTRUDED
F	FAHRENHEIT / FINISH
F TO F	FACE TO FACE
F&C	FRAME AND COVER
F&I	FURNISH AND INSTALL
FAB	FABRICATE / FABRICATION
FAI	FRESH AIR INTAKE
FB	FLAT BAR / FLOOR BEAM / FIELD BOOK
FCO	FLOOR CLEANOUT
FD	FLOOR DRAIN
FDR	FEEDER
FE	FIRE EXTINGUISHER / FINAL EFFLUENT
FEM	FEMALE (PIPE THREAD)
FF	FLAT FACE / FAR FACE / FINISHED FLOOR
FG	FINISHED GRADE
FH	FIRE HYDRANT / FLAT HEAD
FIG	FIGURE
FIN	FINISHED
FIX	FIXTURE
FL	FLOWLINE / FLOOR
FLEX	FLEXIBLE
FLG	FLANGE / FLOORING
FLGD	FLANGED
FLOCC	FLOCCULATOR / FLOCCULATION
FLR	FLOOR
FLSG	FLASHING
FM	FACTORY MUTUAL (LAB. APPROVED) / FORCE MAIN
FMH	FLEXIBLE METAL HOSE
FN	FIELD NAILING
FND	FOUNDATION
FOC	FACE OF CONCRETE / FIBER OPTIC CABLE
FOM	FACE OF MASONRY
FOS	FACE OF STUDS
FOW	FACE OF WALL
FPC	FLEXIBLE PIPE COUPLING
FPM	FEET PER MINUTE
FPS	FEET PER SECOND
FPTS	FOREIGN PIPE TEST STATION
FR	FRAME
FRP	FIBERGLASS REINFORCED PLASTIC
FS	FINISHED SURFACE / FARSIDE / FLOOR SINK / FORGED STEEL / FROTH SPRAY
FT	FEET / FOOT
FTG	FOOTING
FUR	FURRING
FUT	FUTURE
FV	FIELD VERIFY
FWD	FORWARD
G	GAS
GA	GAGE / GAUGE
GAL	GALLON
GALV	GALVANIZED
GANC	GUY ANCHOR
GB	GRADE BREAK
GEN	GENERAL / GENERATOR
GFA	GROOVED FLANGE ADAPTER
GI	GALVANIZED IRON
GIP	GALVANIZED IRON PIPE
GL	GLASS / GROUND LINE / GRADE LINE
GLB	GLUE LAMINATED BEAM
GLV	GLOBE VALVE
GM	GAS METER
GP	GUY POLE
GPD	GALLONS PER DAY
GPH	GALLONS PER HOUR
GPM	GALLONS PER MINUTE
GR	GRADE
GRD	GRADE / GROUND
GRTG	GRATING
GSP	GALVANIZED STEEL PIPE
GV	GATE VALVE
GYP	GYPSUM
H	HIGH / HEIGHT
H&V	HEATING AND VENTILATING
H/B	HOSE BIBB
HC	HOUSE CONNECTION
HDR	HEADER
HDW	HARDWARE
HDWL	HEADWALL
HEX	HEXAGONAL
Hg	MERCURY
HGL	HYDRAULIC GRADE LINE
HGR	MANGER
HM	HOLLOW METAL
HORZ	HORIZONTAL
HP	HIGH POINT / HORSE POWER / HIGH PRESSURE
HPG	HIGH PRESSURE GAS
HR	HEAT RETURN / HOUR
HTG	HEATING
HTR	HEATER
HV	HORIZONTAL AND VERTICAL CONTROL POINT
HVAC	HEATING, VENTILATION AND AIR CONDITIONING
HW	HOT WATER / HEADWORK
HWD	HARDWOOD
HWL	HIGH WATER LEVEL
HWO	HANDWHEEL OPERATED
HYD	HYDRAULIC / HYDRANT
IAS	INSITU AIR SPARGING
I&O	INSIDE AND OUTSIDE
ID	INSIDE DIAMETER
IF	INSIDE FACE
IJTS	INSULATING JOINT TEST STATION
IN	INCH
INCL	INCLUDE / INCLUDING
INFL	INFLUENT
INSL	INSULATION
INSP	INSPECTION
INST	INSTRUMENT
INT	INTERIOR
INV	INVERT
IP	IRON PIPE
IPS	IRON PIPE SIZE
IRRG	IRRIGATION
ISVE	INSITU SOIL VAPOR EXTRACTION
JAN	JANITOR
JC	JUNCTION CHAMBER
JCT	JUNCTION
JS	JUNCTION STRUCTURE
JSTS	JOISTS
JT	JOINT
K	KELVIN / KILO / KARAT
KG	KILOGRAM
KM	KILOMETER
KV	KILOVOLT
KW	KILOWATT
KWH	KILOWATT HOUR
L	LITER / LENGTH / ANGLE
LAB	LABORATORY
LAM	LAMINATED
LAT	LATERAL
LAV	LAVATORY
LB	POUND
LCP	LOCAL CONTROL PANEL
LD	LOCAL DEPRESSION
LDG	LANDING
LEV	LEVEL
LF	LINEAR FOOT
LG	LENGTH / LONG
LH	LAMP HOLE / LEFT HAND
LL	LIVE LOAD
LLH	LONG LEG HORIZONTAL
LLV	LONG LEG VERTICAL
LOC	LOCATION
LOL	LAYOUT LINE
LONG	LONGITUDINAL
LP	LOW POINT / LOW PRESSURE / LAMP POST
LT	LEFT / LIGHT
LTS	LIME TREATED SOIL
LW	LOW WATER
LWL	LOW WATER LEVEL
LWR	LOWER
M	METER / MALE (PIPE THREAD)
MACH	MACHINE
MAG	MAGNETIC
MAINT	MAINTENANCE
MAN	MANUAL
MAS	MASONRY
MATL	MATERIAL
MAX	MAXIMUM
MB	MAIL BOX / MACHINE BOLT
MCC	MOTOR CONTROL CENTER
MCR	MIDDLE OF CURB RETURN
MEAS	MEASURE
MECH	MECHANICAL
MED	MEDIUM
MEMB	MEMBER
MFRD	MANUFACTURED
MGD	MILLION GALLONS PER DAY
MH	MANHOLE
MHT	MEAN HIGH TIDE
MHW	MEAN HIGH WATER
MI	MALLEABLE IRON / MILE
MICRON	1/1,000,000 METER
MIL	MILITARY / 1/1,000 TH INCH
MIN	MINIMUM / MINUTE
MIR	MIRROR
MISC	MISCELLANEOUS
MK	MARK
MLW	MEAN LOW WATER
mm	MILLIMETER
MO	MOTOR OPERATED / MASONRY OPENING
MOD	MODEL
MON	MONUMENT
MOR	MORTAR
MS	MOP SINK
MSL	MEAN SEA LEVEL
MTC	MECHANICAL-TYPE COUPLING
MTD	MOUNTED
MTG	MOUNTING
MTL	METAL
MTR	MOTOR
N	NORTH
NaOCL	SODIUM HYPOCHLORITE
NaOH	SODIUM HYDROXIDE (CAUSTIC SODA)
NBS	NATIONAL BUREAU OF STANDARDS
NC	NORMALLY CLOSED
NEC	NATIONAL ELECTRICAL CODE
NEMA	NATIONAL ELECTRICAL MANUFACTURES ASSOCIATION
NF	NEAR FACE
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
NG	NATURAL GRADE / NATURAL GAS
NIC	NOT IN CONTRACT
NO	NUMBER / NORMALLY OPEN
NOM	NOMINAL
NPS	NOMINAL PIPE SIZE
NPT	NATIONAL PIPE THREAD
NRCP	NONREINFORCED CONCRETE PIPE
NRS	NON-RISING STEM
NS	NEAR SIDE
NTS	NOT TO SCALE
OBJ	OBJECT
OC	ON CENTER / OVER-CROSSING
OD	OUTSIDE DIAMETER / OVERALL DIMENSION
OE	OUTER EDGE
OF	OVERFLOW / OUTSIDE FACE
OFD	OVERFLOW DRAIN
OFF	OFFICE
OH	OVER HEAD
OPER	OPERATOR / OPERATING
OPNG	OPENING
OPP	OPPOSITE
ORC	OXYGEN RELEASE COMPOUND
ORIG	ORIGINAL
OS&Y	OUTSIDE SCREW AND YOKE
OSA	OUTSIDE AIR
OSHA	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
OWG	OIL. WATER. GAS
OZ	OUNCE
P	POLE / PAGE / PIPE
P/S	POLE AND SHELF
PA	PLANTING AREA
PART	PARTITION
PAVMT	PAVEMENT
PB	POLYBUTYLENE / PULL BOX
PC	POINT OF CURVATURE / PRIMARY CLARIFIER / PORTLAND CEMENT
PCC	PORTLAND CEMENT CONCRETE / POINT OF COMPOUND CURVE
PCOTG	PRESSURE CLEANOUT TO GRADE
PCVC	POINT OF COMPOUND VERTICAL CURVE
PE	POLYETHYLENE / PLANT EFFLUENT / POLYELECTROLYTE POLYMER
PG	PRESSURE GAGE
pH	HYDROGEN ION CONCENTRATION
PI	PLANT INFLUENT / POINT OF INTERSECTION
PK	PARKING
PL	PLATE / PROPERTY LINE / PLACE
PLAS	PLASTER / PLASTIC
PLT	PLANT
PLWD	PLYWOOD
PM	PRESSED METAL
PNEU	PNEUMATIC
PNL	PANEL
POB	POINT OF BEGINNING
POC	POINT OF CONNECTION
POT	POINT OF TANGENT
PP	POWER POLE / POLYPROPYLENE
PPD	POUNDS PER DAY
PPH	POUNDS PER HOUR
PPM	POUNDS PER MINUTE
PR	PAIR
PRC	POINT OF REVERSE CURVE
PRCT	PRECAST
PREFAB	PREFABRICATED
PRESS	PRESSURE
PROF	PROFILE
PRV	PRESSURE REGULATING, RELIEF OR REDUCING VALVE
PRVC	POINT OF REVERSE VERTICAL CURVE
PS	PRESSURE SWITCH
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
PSIA	POUNDS PER SQUARE INCH ABSOLUTE
PSIG	POUNDS PER SQUARE INCH GAUGE
PT	POINT OF TANGENCY / PAINT / PRESSURE TREATED
PTFE	POLYTETRAFLUOROETHYLENE (TEFLON)
PV	PLUG VALVE
PVC	POLYVINYL CHLORIDE
PVDF	POLYVINYLIDENE FLUORIDE (KYNAR)
QT	QUARRY TILE
QTY	QUANTITY
QUAD	QUADRANGLE / QUADRANT
R	RADIUS / RISER / RATE OF SLOPE
R&O	ROCK AND OIL
R/W	RIGHT OF WAY
RAC	RECYCLED ASPHALT CONCRETE
RAG	RETURN AIR GRILLE
RAP	RECLAIMED ASPHALT PAVEMENT
RAS	RETURN ACTIVATED SLUDGE
RC	REINFORCED CONCRETE
RCP	REINFORCED CONCRETE PIPE
RD	ROAD / ROOF DRAIN / ROUND
RED	REDUCER / REDUCING
REF	REFERENCE / REFER / REFRIGERATOR
REG	REGULATING
REINF	REINFORCE / REINFORCED
REQD	REQUIRED
RESIL	RESILIENT
RET	RETAINING / RETURN
REV	REVISION
RF	ROOF / RAISED FOUNDATION / ROUGH FACE
RFG	ROOFING
RGE	REGISTERED GEOTECHNICAL ENGINEER
RH	REDHEAD / RIGHT HAND
RM	ROOM
RO	ROUGH OPENING
RPM	REVOLUTIONS PER MINUTE
RR	RAILROAD
RS	RISING STEM
RSL	RAW SLUDGE
RT	RIGHT
RTP	REINFORCED THERMOSETTING PLASTIC
RW	REDWOOD
RWL	RAINWATER LEADER
S	SOUTH / SCUM / SINK / SECOND / SLOPE / SAND
S/O	SOUTH OF
SA	SAMPLE
SAN	SANITARY
SBR	STYRENE BUTADENE (RUBBER)
SC	SPARE CHEMICAL / SECONDARY CLARIFIER
SCCP	STEEL CYLINDER CONCRETE PIPE
SCD	SCREWED
SCFM	STANDARD CUBIC FEET PER MINUTE
SCH	SCHEDULE
SD	STORM DRAIN
SDR	STANDARD THERMOPLASTIC PIPE DIMENSION RATIO
SEC	SECONDARY / SECTION
SER	SERIES
SETT	SETTING
SF	SQUARE FOOT
SH	SHOWER
SHELV	SHELVING
SHT	SHEET
SHTG	SHEATHING
SIM	SIMILAR
SL	SLUDGE
SLDG	SLIDING
SLG	SLUICE GATE
SOG	SLAB ON GRADE
SOLN	SOLUTION
SP	STATIC PRESSURE
SPEC	SPECIFICATION
SPK	SPIKE
SQ	SQUARE
SS	STAINLESS STEEL / SANITARY SEWER / SERVICE SINK
SSB	SELECT SUB-BASE
SSPWC	STANDARD SPECIFICATION FOR PUBLIC WORKS CONSTRUCTION
SSU	SECONDS SAYBOLT UNIVERSAL
ST	STREET / STATE
STA	STATION
STC	SLEEVE-TYPE COUPLING
STD	STANDARD
STK	STAKE
STL	STEEL
STM	STEAM
STR	STRAIGHT / STRUCTURAL
SUCT	SUCTION
SV	SOLENOID VALVE
SW	SIDEWALK
SWD	SIDEWALK DRAIN
SWGR	SWITCHGEAR
SWR	SIDEWALL REGISTER
SY	SQUARE YARD
SYM	SYMMETRICAL / SYMBOL
SYS	SYSTEM
T	THERMOSTAT / TREAD OF STAIR / TANGENT / TOP
T&B	TOP AND BOTTOM
T&G	TONGUE AND GROOVE
TAN	TANGENT
TB	TACK BOARD
TBE	THREAD BOTH ENDS
TBM	TEMPORARY BENCH MARK
TC	TOP OF CURB
TCV	TEMPERATURE CONTROL VALVE
TEL	TELEPHONE
TEMP	TEMPERATURE / TEMPORARY
TF	TOP OF FOOTING
TH	TEST HOLE
THK	THICK / THICKNESS
THR	THRESHOLD
THR'D	THREADED
TK	TANK / TACK
TL	TRAVERSE LINE
TOC	TOP OF CONCRETE
TOE	THREAD ONE END
TOL	TOILET
TOM	TOP OF MASONRY
TOP	TOP OF PIPE
TOPO	TOPOGRAPHIC
TOS	TOP OF STEEL
TOW	TOP OF WALL
TP	TELEPHONE POLE
TR	TRACT
TRANS	TRANSMITTER / TRANSITION /TRANSMISSION
TS	TRAFFIC SIGNAL
TSB	TOP SET BASE
TSC	TRAFFIC SIGNAL CONDUIT
TV	THERMOSTATIC VALVE / TELEVISION
TW	THERMOMETER WELL /TRAVELED WAY
TYP	TYPICAL
UB	UNION BONNET
UBC	UNIFORM BUILDING CODE
UC	UNDER-CROSSING
UG	UNDERGROUND
UGC	UNDERGROUND CONDUIT
UH	UNIT HEATER
UL	UNDERWRITERS LABORATORIES
UNO	UNLESS NOTED OTHERWISE
UOI	UNLESS OTHERWISE INDICATED
UR	URINAL
USA	UNDERGROUND SERVICE ALERT
USGS	UNITED STATES GEOLOGICAL SURVEY
V	VALVE / VERTICAL / VENT / VOLT / VOLUME
VAC	VACUUM
VAR	VARIES / VARIABLE
VB	VALVE BOX
VC	VERTICAL CURVE
VCP	VITRIFIED CLAY PIPE
VERT	VERTICAL
VOL	VOLUME
VPI	VERTICAL POINT OF INTERSECTION
VTC	VENT TO CEILING
VTR	VENT THROUGH ROOF
VWC	VINYL WALL COVERING
VWM	VERIFY WITH MANUFACTURE
W	WEST / WASTE / WIDTH / WIDE FLANGE
W/	WITH
W/O	WEST OF / WITHOUT
WC	WATER COLUMN / WATER CLOSET
WCO	WALL CLEANOUT
WD	WOOD
WDW	WINDOW
WH	WATER HEATER
WI	WROUGHT IRON
WM	WATER METER
WOG	WATER, OIL, OR GAS
WP	WATER PROOFING / WORKING PRESSURE / WORK POINT
WPJ	WEAKEN PLANE JOINT
WS	WATER SURFACE
WSTP	WATER STOP
WT	WEIGHT
WWF	WELDED WIRE FABRIC
WWP	WATER WORKING PRESSURE
XCONN	CROSS CONNECTION
XS	EXTRA STRONG
XSEC	CROSS SECTION
XXS	DOUBLE EXTRA STRONG
YD	YARD
YR	YEAR
Z	ZERO / ZONE
ZN	ZINC
#	POUND
&	AND
@	AT

NOTE:

SITE SPECIFIC ABBREVIATIONS MAY BE FOUND ON THE ACRONYMS LIST ON PAGE VII OF THE FINAL RD DOCUMENT

FOR ADDITIONAL ABBREVIATIONS SEE:

PIPING - SHEET •
ELECTRICAL - SHEET •
INSTRUMENTATION - SHEET •

OTHER ABBREVIATIONS CONFORM TO ANSI STANDARD ABBREVIATIONS Z32.2.3

REV 042898

Plot Date: $$$$date$$$$ $$time$$
File: J:\1252\042\028\drawings\gen\gabr1042.dgn
Job No: MW Job #

REV	DATE	BY	DESCRIPTION

SCALE: NONE

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED
DRAWN
CHECKED

SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) — IN-19600482 LICENSE NO. — DATE
(COMPANY OFFICER) — LICENSE NO. — DATE

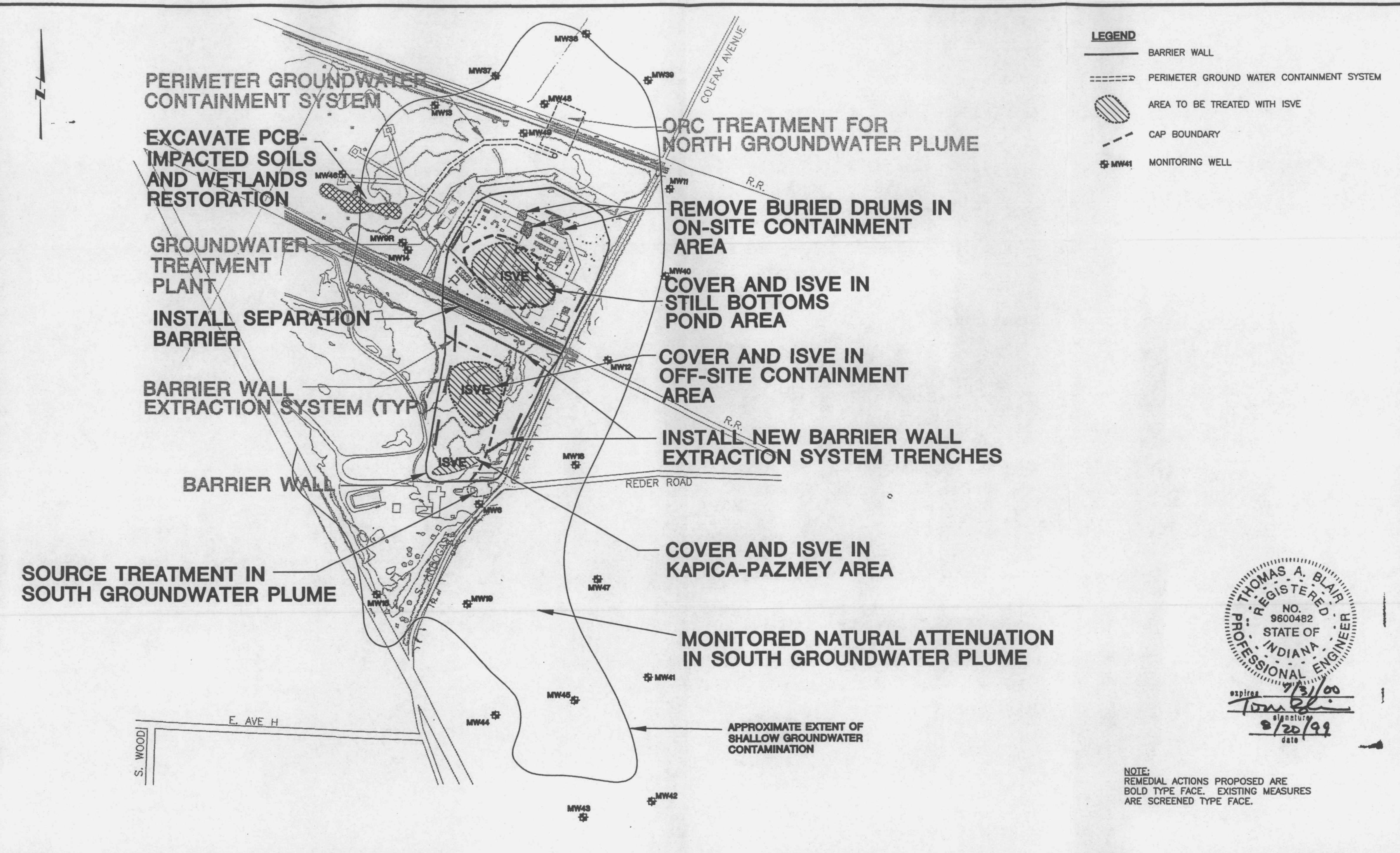
MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN

GENERAL STANDARD ABBREVIATION SHEET

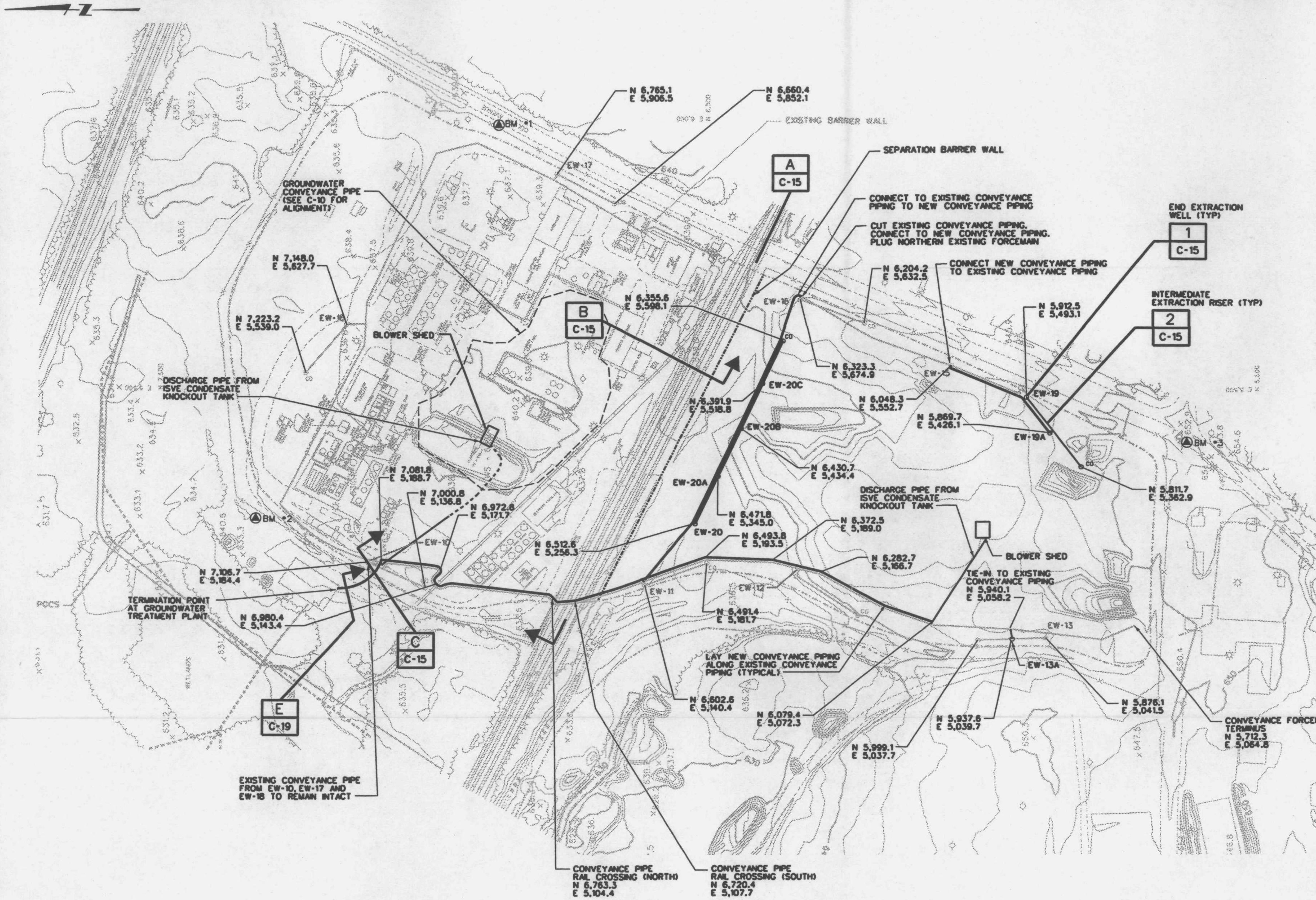
SHEET G-3



NOTE:
REMEDIAL ACTIONS PROPOSED ARE BOLD TYPE FACE. EXISTING MEASURES ARE SCREENED TYPE FACE.

Job No: MW Job # File: j:/1252/042/28/revised/civ/acs28c11.dwg Plot Date: $$$date$$$ $$time$$

REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY						SHEET
				1" = 250'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED TAB DRAWN RBA CHECKED TAB	TOM BLAIR (PROJECT MANAGER) (COMPANY OFFICER)	IN-19600482 LICENSE NO. LICENSE NO.	DATE DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN OVERALL REMEDIAL ACTIONS PLAN	C-1



LEGEND

CO	CLEANOUT AT END OF EXTRACTION TRENCH
EW-20	EXTRACTION WELL LOCATED AT END OF EXTRACTION TRENCH (SEE DETAIL 1, SHEET C-12)
EW-20A	EXTRACTION WELL LOCATED ALONG EXTRACTION TRENCH (SEE DETAIL 2, SHEET C-12)
	EXISTING CONVEYANCE PIPING
EW-11 — CO	EXISTING EXTRACTION TRENCH
	PROPOSED CONVEYANCE PIPING
EW-19 — CO	PROPOSED EXTRACTION TRENCH

BENCHMARKS:

BM #1 : REBAR
N. 6871.36
E. 5996.85
EL. 638.95 ft-MSL

BM #2 : REBAR
N. 7312.73
E. 5266.80
EL. 634.98 ft-MSL

BM #3 : REBAR
N. 5619.76
E. 5408.62
EL. 653.54 ft-MSL

NOTE:

MEASUREMENTS FROM CONTROL POINTS BM # 1,2, AND 3 WERE RECORDED USING THE TOP OF A STATIONARY IRON PIPE

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00
Tom Blair
signature
8/20/99
date

Job No: MW Job # File: J:/1252/042/drawings/civ/acs28c01.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION

SCALE: 1" = 100'-0"

WARNING: 0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED ____
DRAWN ____
CHECKED ____

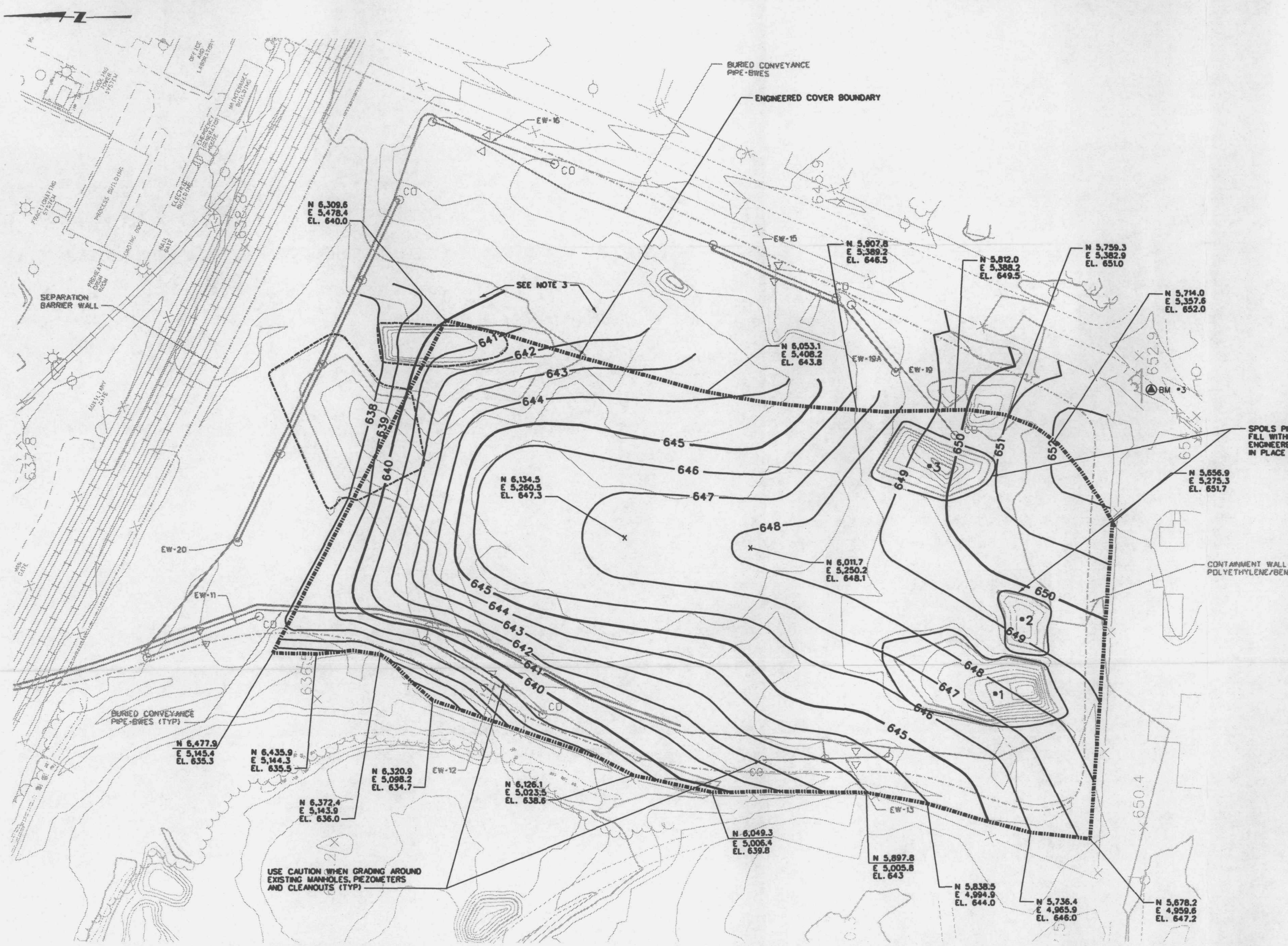
SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE
(COMPANY OFFICER) LICENSE NO. DATE

MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
BARRIER WALL AND BARRIER WALL EXTRACTION SYSTEM PIPING LAYOUT

SHEET C-2



LEGEND:

- 640 — PROPOSED CONTOURS
- EXISTING CONTOURS
- △ EXISTING PIEZOMETERS
- •1 SPOILS PILES (3 TOTAL) TO BE RELOCATED WITHIN SUBGRADE LAYER
- WASTE PILES TO BE USED AS GENERAL FILL WITHIN SUBGRADE LAYER
- EXISTING/PROPOSED BWES TRENCHES
- CONTAINMENT BARRIER WALL
- SEPARATION BARRIER WALL
- DELINEATION OF OFCA ENGINEERED COVER

BENCHMARK:

BM •3 : REBAR
N. 5619.76
E. 5408.62
EL. 653.54 ft-MSL

NOTE:

MEASUREMENTS FROM CONTROL POINT BM • 3 WAS RECORDED USING THE TOP OF A STATIONARY IRON PIPE

THOMAS A. BLAIR
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STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00
Tom Blair
signature
8/20/99
date

NOTES:

1. DO NOT REGRADE SPOILS PILE •2 WITHIN AREAS OF ISVE IMPLEMENTATION (SEE SHEETS C-5 AND C-6).
2. CONTOURS SHOWN FOR GRAPHICAL REPRESENTATION ONLY. COORDINATES WILL GOVERN GRADING AND SURVEY LAYOUT.
3. SUBGRADE TO BE BLENDED INTO EXISTING SURFACE AT BOUNDARY.

Job No: MW Job • File: J:/1252/042/28/civ/acs28c07.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION

SCALE 1" = 50'-0"

WARNING 0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED TAB
DRAWN RBA
CHECKED

SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE
(COMPANY OFFICER) LICENSE NO. DATE

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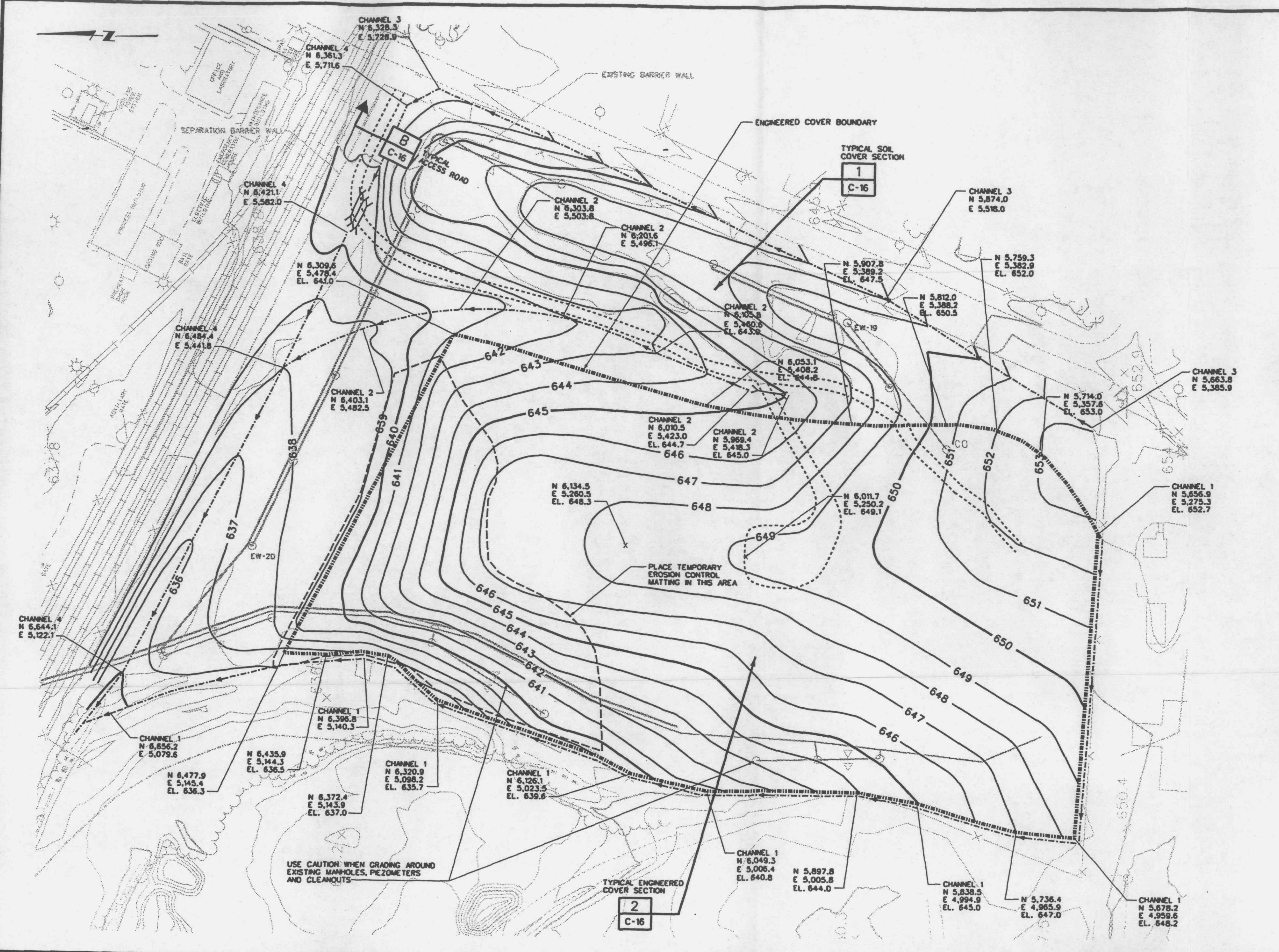
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
OFF-SITE CONTAINMENT AREA SUBBASE CONTOURS

SHEET C-3



LEGEND:

—640—	PROPOSED CONTOURS
	EXISTING CONTOURS
△	EXISTING PIEZOMETERS
	TEMPORARY ACCESS ROAD
	EXISTING BWES TRENCHES
	SEPARATION BARRIER WALL
	CULVERT
	DRAINAGE CHANNEL ALIGNMENT

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

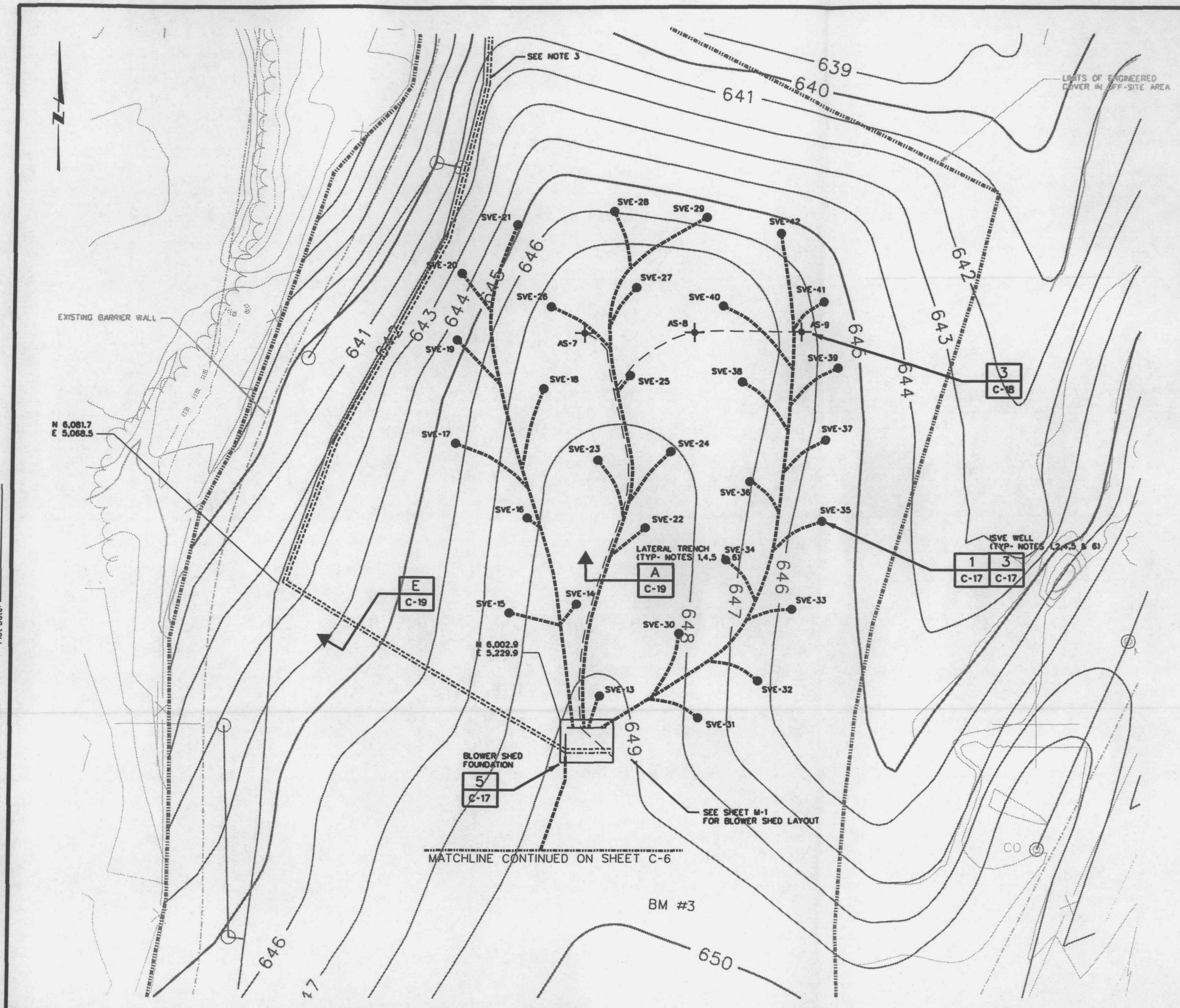
expires 7/31/00
Tom Blair
signature
8/20/99
date

NOTES:

1. CONTOURS SHOWN FOR GRAPHICAL REPRESENTATION ONLY. COORDINATES WILL GOVERN GRADING AND SURVEY LAYOUT.
2. AREA OUTSIDE ENGINEERED COVER TO BE SUPPLEMENTED WITH CLAY SO THAT TOTAL CLAY THICKNESS IS 18". CONTOURS SHOWN FOR GRAPHICAL REPRESENTATION AND TO ILLUSTRATE DRAINAGE PATTERNS.
3. TOP OF CLAY TO BE SMOOTH AND FREE FROM SHARPS AND MATERIALS GREATER THAN 2" PRIOR TO FINAL FML PLACEMENT.
4. SEE SHEETS C-5 AND C-6 FOR ISVE WELL LOCATIONS.

Job No: MW Job # File: J:/1252/042/28/civ/acs28c08.dgn Plot Date: ####date#### ##time##

REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY					SHEET
				1" = 50'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED TAB DRAWN RBA CHECKED	TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE (COMPANY OFFICER) LICENSE NO. DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN	OFF-SITE CONTAINMENT AREA INTERIM COVER SURFACE CONTOURS	C-4



LEGEND:

—640—	TOP OF CLAY CONTOUR ELEVATION
	VAPOR EXTRACTION PIPE ALIGNMENT
	AIR SPARGE SUPPLY PIPE ALIGNMENT
SVE-42	WELL LOCATION
AS-1	AIR SPARGE POINT
	ISVE VAPOR EFFLUENT CONVEYANCE PIPE
	CONDENSATE CONVEYANCE PIPE
	DELINEATION OF OFCA ENGINEERED COVER
	CONTAINMENT BARRIER WALL

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00
Tom Blair
signature
8/20/99
date

NOTES:

1. ACTUAL PIPE LAYOUT AND WELL LOCATIONS TO BE FIELD MODIFIED AS NECESSARY AND APPROVED BY ENGINEER.
2. FOR WELL LOCATIONS, SEE SHEET C-20.
3. RUN ISVE AND CONDENSATE CONVEYANCE PIPE IN SAME TRENCH AS GROUNDWATER CONVEYANCE PIPE.
4. ACTUAL WELL AND PIPE LOCATIONS TO BE SURVEYED PRIOR TO TRENCH BACKFILL.
5. ISVE PIPING AND WELLS AND AIR SPARGE PIPING, AND SPARGE POINTS TO BE INSTALLED THROUGH CLAY LAYER. PIPING INVERT TO SIT AT BOTTOM OF CLAY.
6. CLAY SURFACE AND EROSION CONTROL MEASURES TO BE REPAIRED AND RECOMPACTED FOLLOWING PIPE AND WELL INSTALLATION.
7. AFTER INSTALLATION OF THE ISVE IN THE OFF-SITE CONTAINMENT AREA, THE SYSTEM WILL BE STARTED-UP AND OPERATED IN PHASES. SEE TEXT FOR DESCRIPTION OF PHASED START-UP AND OPERATION.

Job No: MW Job • File: J:/1252/042/28/drawings/civ/ocswel01.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION

SCALE 1"=30'-0"

WARNING 0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED
DRAWN RBA
CHECKED

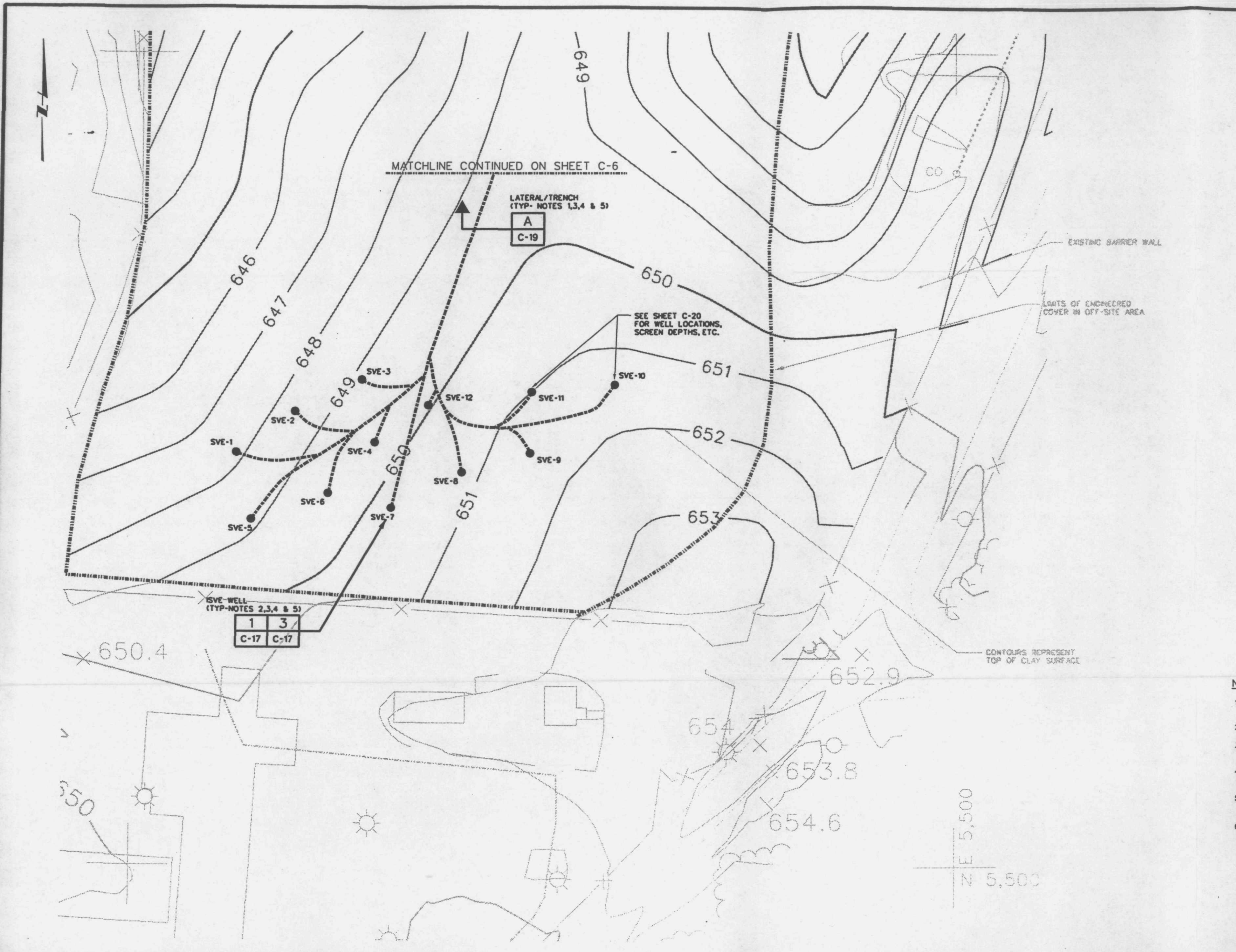
SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE
(COMPANY OFFICER) LICENSE NO. DATE

MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
OFF-SITE CONTAINMENT AREA
ISVE PLAN VIEW AND YARD PIPING

SHEET C-5



LEGEND:

—640—	TOP OF REGRADED CLAY CONTOUR ELEVATION
	BURIED LATERAL ISVE PIPE ALIGNMENT
SVE-10 ●	WELL LOCATION
	DELINEATION OF OFCA ENGINEERED COVER

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

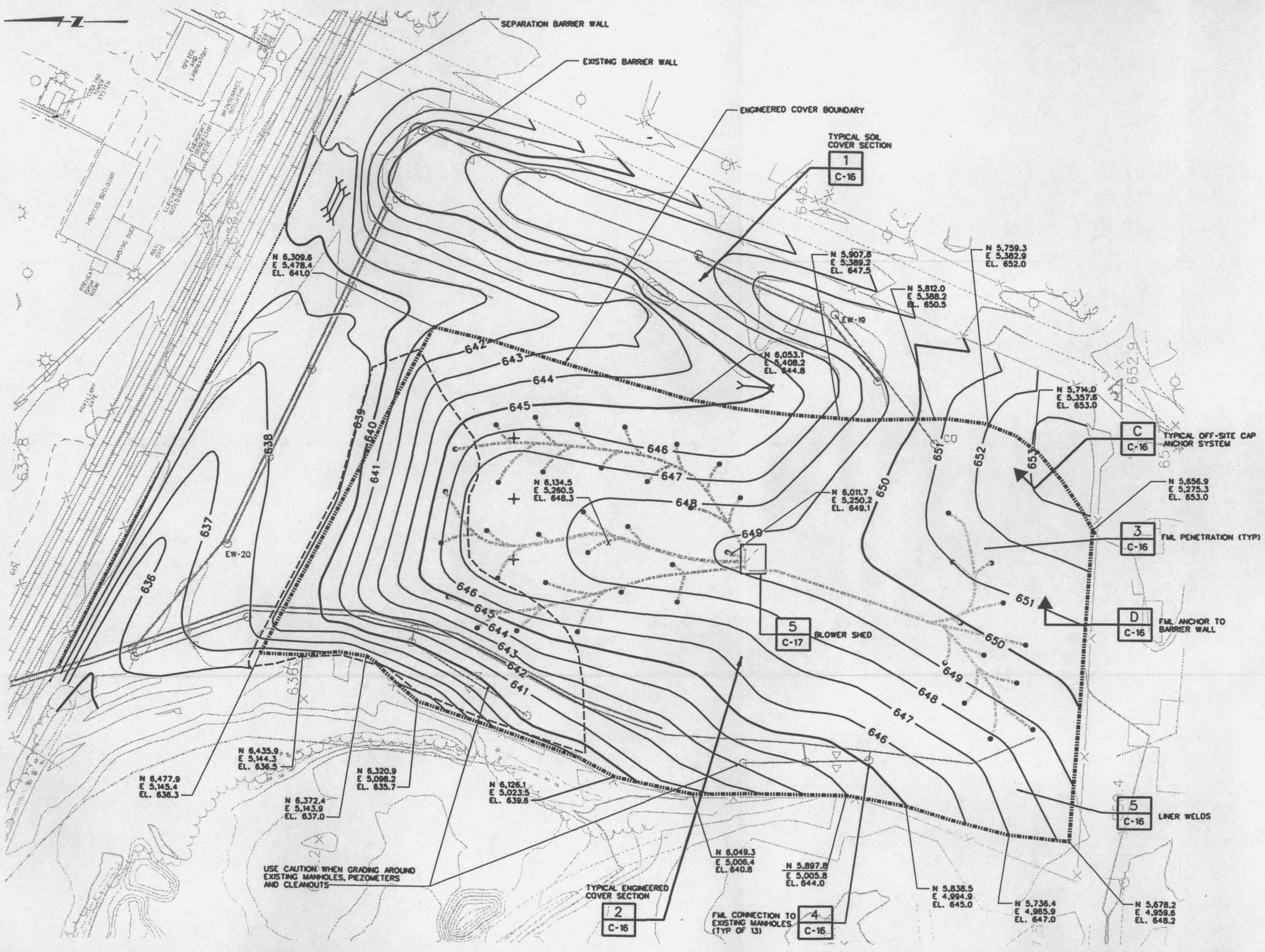
expires 7/31/00
Tom Blair
signature
8/20/99
date

NOTES:

1. ACTUAL PIPE LAYOUT AND WELL LOCATIONS TO BE FIELD MODIFIED AS NECESSARY AND APPROVED BY ENGINEER.
2. FOR WELL LOCATIONS, SEE SHEET C-20.
3. ISVE PIPING AND WELLS, AIR SPARGE PIPING, AND SPARGE POINTS TO BE INSTALLED THROUGH CLAY LAYER. PIPING TO SIT AT BOTTOM OF CLAY.
4. ACTUAL WELL AND PIPE LOCATIONS TO BE SURVEYED PRIOR TO TRENCH BACKFILL.
5. CLAY SURFACE AND EROSION CONTROL MEASURES TO BE REPAIRED AND RECOMPACTED FOLLOWING PIPE AND WELL INSTALLATION.
6. AFTER INSTALLATION OF THE ISVE IN THE KAPICA-PAZMEY AREA, THE SYSTEM WILL BE STARTED-UP AND OPERATED IN PHASES. SEE TEXT FOR DESCRIPTION OF PHASED START-UP AND OPERATION.

Job No: MW Job • File: J:/1252/042/28/drawings/civ/acswel03.dgn Plot Date: ••••date•••• ••time••

REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY				
				1"=30'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED ____ DRAWN RBA CHECKED ____	TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE (COMPANY OFFICER) LICENSE NO. DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN KAPICA-PAZMEY AREA ISVE PLAN VIEW AND YARD PIPING	SHEET C-6



LEGEND:

—640—	PROPOSED CONTOURS
	EXISTING CONTOURS
△	EXISTING PIEZOMETERS
	EXISTING BWES TRENCHES
	SEPARATION BARRIER WALL
	CULVERT
	DELINEATION OF OFCA ENGINEERED COVER

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00

Tom Blair
signature

8/20/99
date

NOTES:

1. CONTOURS SHOWN FOR GRAPHICAL REPRESENTATION ONLY. COORDINATES WILL GOVERN GRADING AND SURVEY LAYOUT.
2. AREA OUTSIDE ENGINEERED COVER TO BE SUPPLEMENTED WITH CLAY SO THAT TOTAL CLAY THICKNESS IS 18". CONTOURS SHOWN FOR GRAPHICAL REPRESENTATION AND TO ILLUSTRATE DRAINAGE PATTERNS.
3. TOP OF CLAY TO BE SMOOTH AND FREE FROM SHARPS AND MATERIALS GREATER THAN 2" PRIOR TO FINAL FML PLACEMENT. FOLLOWING INSTALLATION OF ISVE WELLS, FML TO BE PLACED AND BOOTED TO EACH WELL (SEE DETAIL 3, SHEET C-17).

Job No: MW Job # File: J:/1252/042/28/drawings/civ/acs28c13.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION

SCALE 1" = 50'-0"

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED TAB
DRAWN RBA
CHECKED

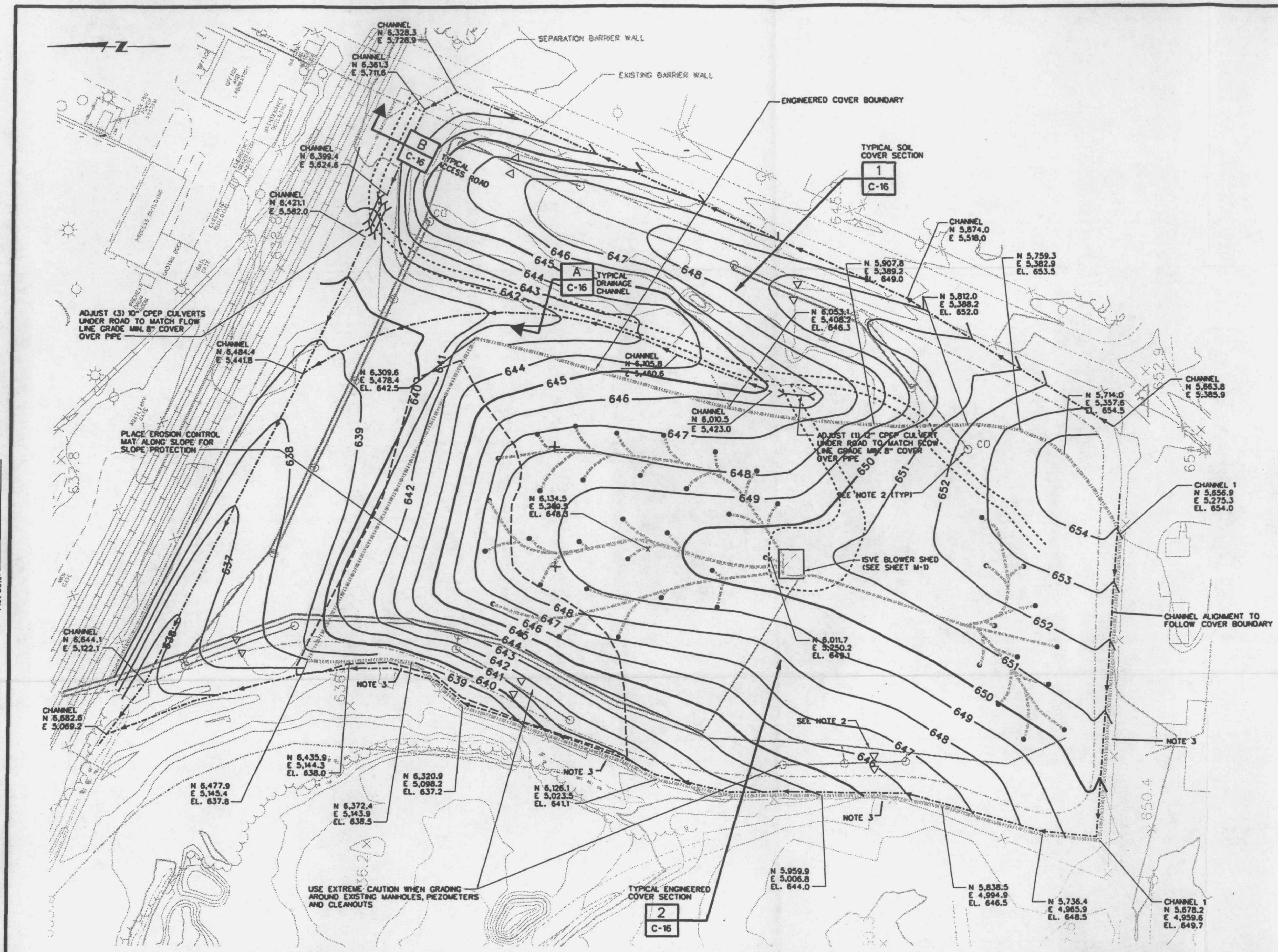
SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) — IN-19600482 LICENSE NO. — DATE
(COMPANY OFFICER) — LICENSE NO. — DATE

MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
OFF-SITE CONTAINMENT AREA
TOP OF FML CONTOURS

SHEET C-7



LEGEND:

—640—	PROPOSED CONTOURS
	EXISTING CONTOURS
△	EXISTING PIEZOMETERS
	ACCESS ROAD
	EXISTING BWES TRENCHES
	SEPARATION BARRIER WALL
•	ISVE WELL LOCATION
	DRAINAGE CHANNEL CENTER LINE

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00
Tom Blair
signature
8/20/99
date

NOTES:

1. ALL DRAINAGE CHANNELS TO BE LINED WITH EROSION CONTROL MAT. SEE DETAIL A, SHEET C-16.
2. ALL MANHOLES, CLEANOUTS TO BE RAISED TO MATCH FINAL GRADE PLUS 6". PIEZOMETERS TO BE RAISED TO MATCH FINAL GRADE PLUS 30".
3. TOP OF OFCA ENGINEERED COVER EDGE WILL BLEND WITH EXISTING CONTOURS.

REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY		
				1" = 50'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED TAB DRAWN RBA CHECKED	TOM BLAIR (PROJECT MANAGER) (COMPANY OFFICER)	IN-19600482 LICENSE NO. LICENSE NO.	DATE DATE

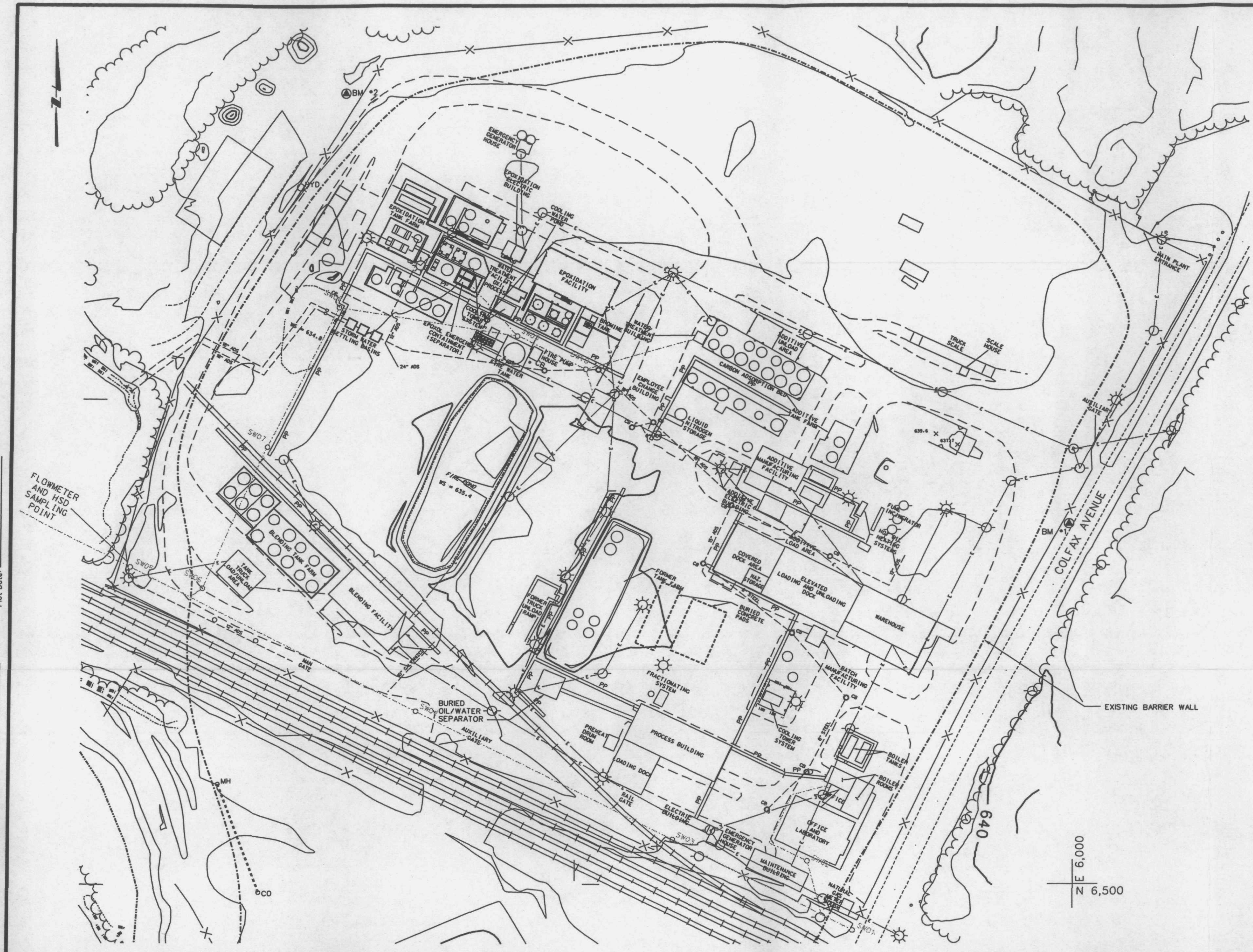
MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
OFF-SITE CONTAINMENT AREA COVER CONTOURS AND STORM WATER CONTROL

SHEET C-8

Job No: MW Job # File: p:/1252/042/28/civ/acs28c09.dgn Plot Date: $$$$date$$$$ $$$time$$



LEGEND:

24" ADS	RUNOFF CATCH BASIN LINE
	STORM WATER LINE
E	OVERHEAD UTILITY LINE
PP	ABOVE GROUND PROCESS PIPING LINE

BENCHMARKS:

BM #1 : REBAR
N.6871.63
E. 5996.85
638.95 ft-MSL

BM #2 : REBAR
N.7312.73
E. 5266.80
634.98 ft-MSL

NOTE:

MEASUREMENTS FROM CONTROL POINTS BM # 1, AND 2, WERE RECORDED USING THE TOP OF A STATIONARY IRON PIPE

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00

Tom Blair
signature

8/20/99
date

Plot Date: $$$date$$$ $$time$$

File: J:/1252/042/28/civ/acs28c12.dgn

Job No: MW Job #

REV	DATE	BY	DESCRIPTION

SCALE: 1" = 50'-0"

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED TAB
DRAWN RBA
CHECKED

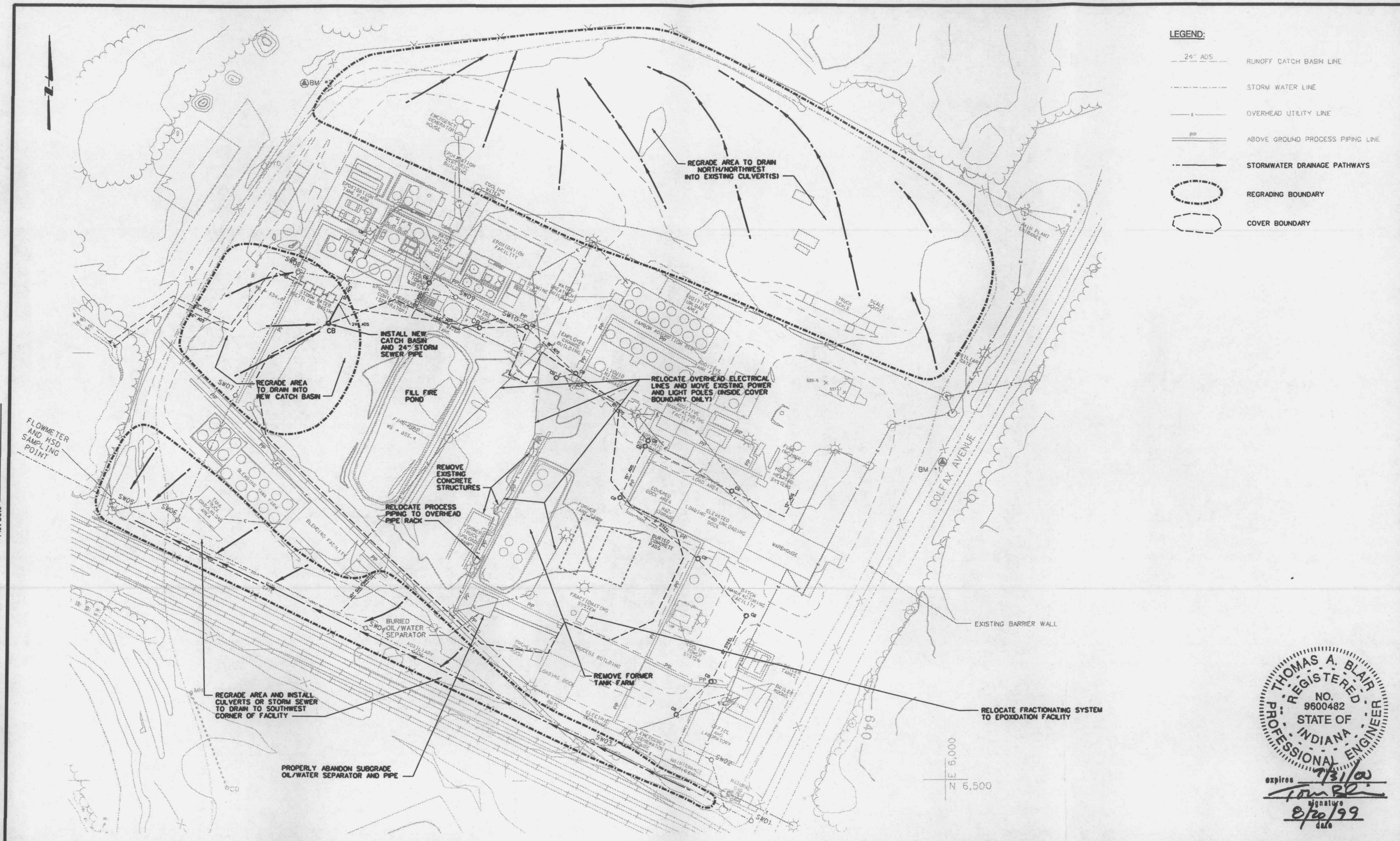
SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) — IN-19600482 LICENSE NO. — DATE
(COMPANY OFFICER) — LICENSE NO. — DATE

MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

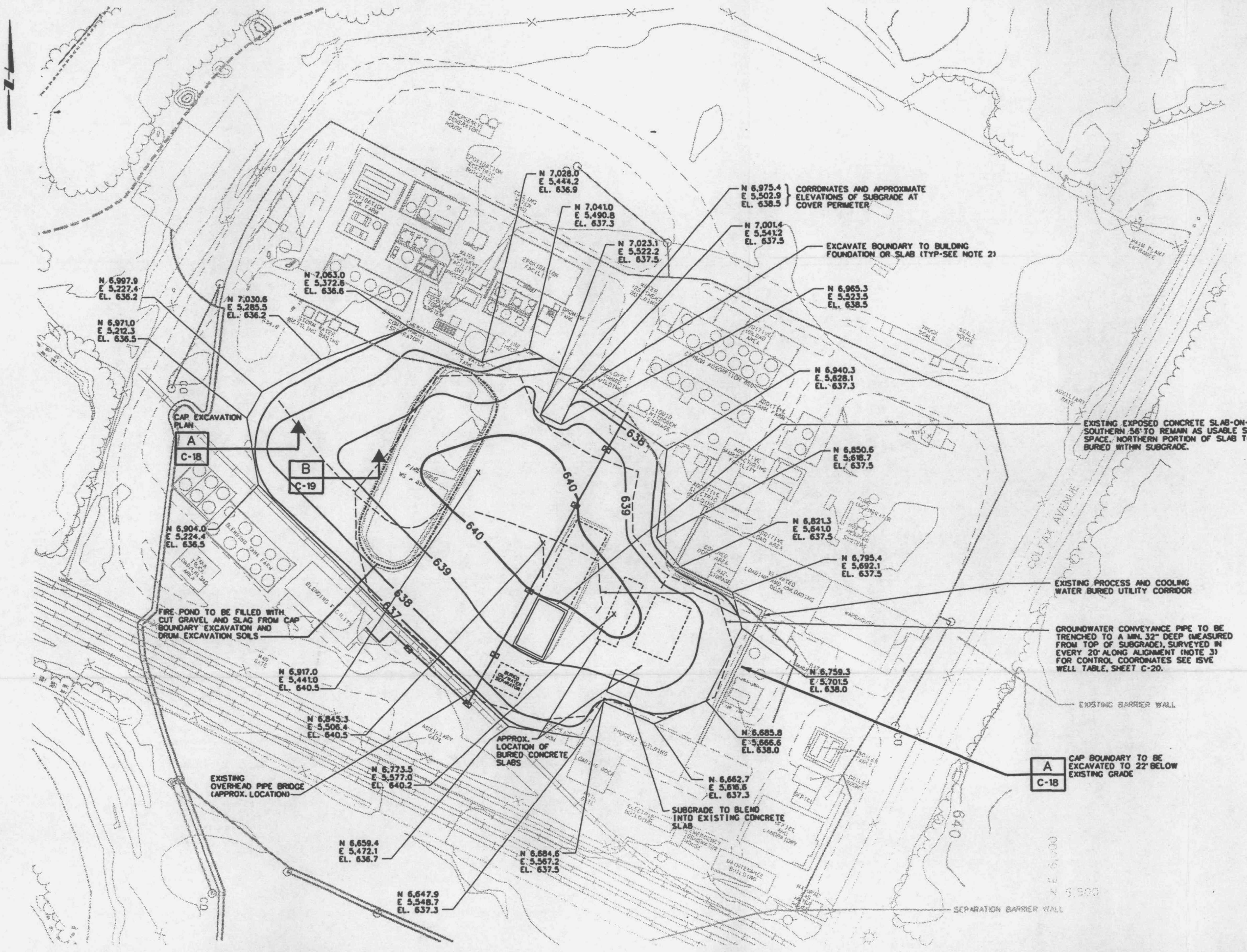
100% REMEDIAL DESIGN
STILL BOTTOMS POND AREA
EXISTING CONDITIONS

SHEET
C-9



Job No: MW Job • File: J:/1252/042/28/civ/acs28c14.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY				
				1" = 50'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED TAB DRAWN RBA CHECKED	TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE (COMPANY OFFICER) LICENSE NO. DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN STILL BOTTOMS POND AREA SITE PREPARATION ACTIVITIES	SHEET C-9A



LEGEND:

—640—	SUBBASE CONTOUR ELEVATION
-·-·-·-·-	ISVE CONVEYANCE PIPE LOCATION
-----------	CONDENSATE CONVEYANCE PIPE
— — — —	GROUND WATER CONVEYANCE PIPE FROM DUAL EXTRACTION WELLS

NOTES:

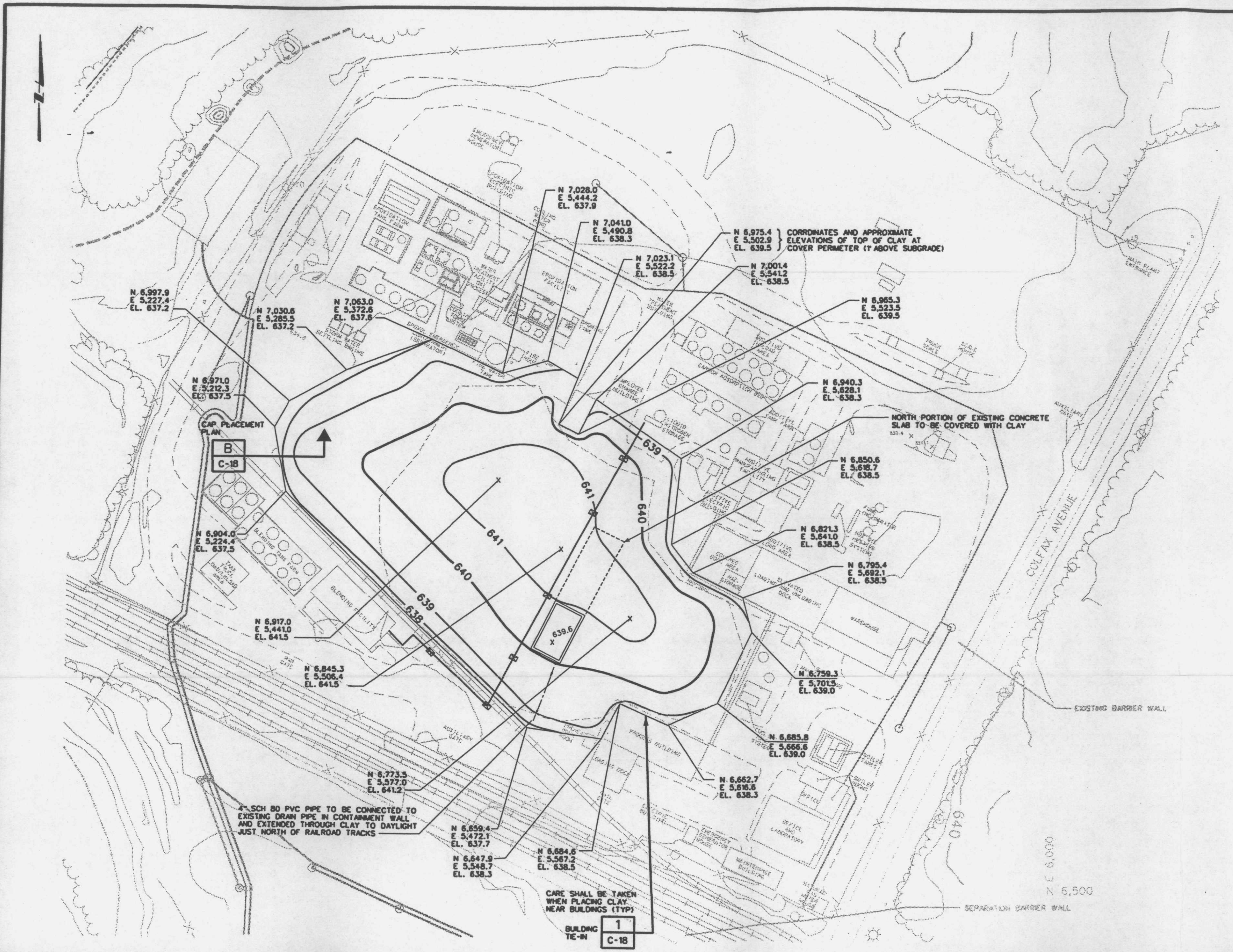
1. CONTOURS SHOWN FOR GRAPHICAL REPRESENTATION ONLY. COORDINATES WILL GOVERN GRADING AND SURVEY LAYOUT.
2. EXCAVATION NEAR BUILDINGS AND TANK PAD TO BE DONE SO AS NOT TO DAMAGE ANY EXISTING STRUCTURE OR FOUNDATION.
3. SPOIL FROM CONVEYANCE PIPE TRENCH TO BE MOVED TO OFF-SITE AREA FOR PLACEMENT UNDER ENGINEERED COVER.

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER
expires 7/31/00
signature
8/20/99
date

Job No: MW Job • File: J:/1252/042/28/civ/acs28c04.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY						
				1" = 50'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED TAB DRAWN RBA CHECKED	TOM BLAIR (PROJECT MANAGER) / (COMPANY OFFICER)	IN-19600482 LICENSE NO. / LICENSE NO.	DATE / DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN STILL BOTTOMS POND AREA COVER SUBBASE CONTOURS	SHEET C-10

Job No: MW Job # File: J:/1252/042/28/civ/acs28c05.dgn Plot Date: $$$$date$$$$ $$time$$



LEGEND:

—640— CLAY CONTOUR ELEVATION

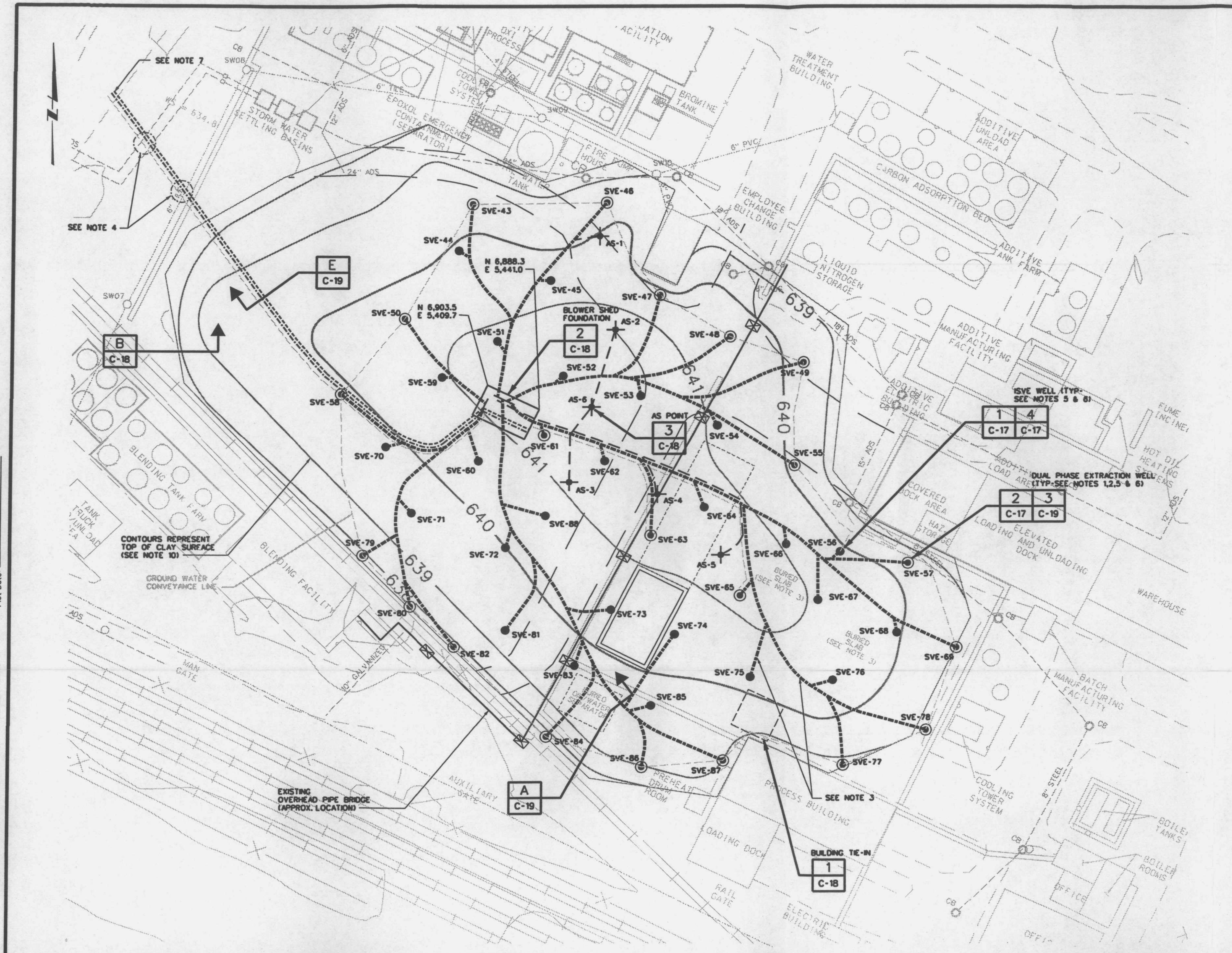
—·—·— DRAIN FOR SLAB CONTAINMENT

NOTES:

1. CONTOURS SHOWN FOR GRAPHICAL REPRESENTATION ONLY. COORDINATES WILL GOVERN GRADING AND SURVEY LAYOUT.
2. CLAY PLACEMENT NEAR BUILDINGS AND TANK PAD TO BE DONE SO AS NOT TO DAMAGE ANY EXISTING STRUCTURE OR FOUNDATION.

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER
expires 7/31/00
signature
date 8/20/99

REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY					SHEET
				1" = 50'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED TAB DRAWN RBA CHECKED	TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE (COMPANY OFFICER) LICENSE NO. DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN	STILL BOTTOMS POND AREA COVER TOP OF CLAY CONTOURS	C-11



LEGEND:

—640—	CLAY CONTOUR ELEVATION
	VAPOR EXTRACTION LATERAL PIPE ALIGNMENT
	AIR SPARGE SUPPLY PIPE ALIGNMENT
	ISVE VAPOR EFFLUENT CONVEYANCE PIPE LOCATION
	GROUND WATER CONVEYANCE PIPE FROM DUAL EXTRACTION WELLS
	CONDENSATE CONVEYANCE PIPE
	STORM SEWER LINE
	SANITARY SEWER LINE
SVE-54	ISVE WELL LOCATION
SVE-55	DUAL PHASE WELL LOCATION
AS-1	AIR SPARGE POINT
	PROPOSED ROADWAY THROUGH WELL FIELD
CB	CATCH BASIN
	SEWER WATER MAN...

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER

expires 7/31/00
signature
date 8/20/99

NOTES:

1. PERIMETER WELLS AND THREE INTERIOR WELLS ARE DUAL EXTRACTION WELLS. SEE SHEET C-20.
2. ISVE WELL DEPTHS AS NOTED ON SHEET C-20.
3. BURIED 12-INCH THICK REINFORCED CONCRETE FOUNDATIONS. CUT OR CORE THROUGH FOUNDATIONS AS NEEDED. BURIED PIPE TO BE INSTALLED ABOVE FOUNDATIONS.
4. ISVE/GROUNDWATER CONVEYANCE LINES TO BE RUN UNDER EXISTING UTILITIES.
5. ISVE WELL LOCATION COORDINATES SHOWN ON SHEET C-20. ACTUAL PIPE LAYOUT AND WELL LOCATIONS TO BE FIELD MODIFIED AS NECESSARY.
6. PLACE DRILL CUTTINGS AND TRENCH SPOILS IN DESIGNATED AREA OF OFF-SITE CONTAINMENT AREA UNDER ENGINEERED COVER. SEE SHEET C-4.
7. RUN ISVE AND CONDENSATE CONVEYANCE PIPE IN SAME TRENCH AS GROUNDWATER CONVEYANCE PIPE.
8. CLAY SURFACE TO BE REPAIRED AND RECOMPACTED FOLLOWING PIPE AND WELL INSTALLATION.
9. ACTUAL WELL AND PIPE LOCATIONS TO BE SURVEYED PRIOR TO TRENCH BACKFILL.
10. CLAY SURFACE TO BE REPAIRED AND RECOMPACTED FOLLOWING PIPE AND WELL INSTALLATION.

Job No: MW Job # File: J:/1252/042/28/drawings/civ/acswel02.dgn Plot Date: $$$$date$$$$ $$time$$

REV	DATE	BY	DESCRIPTION

SCALE 1"=30'-0"

WARNING 0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED
DRAWN RBA
CHECKED

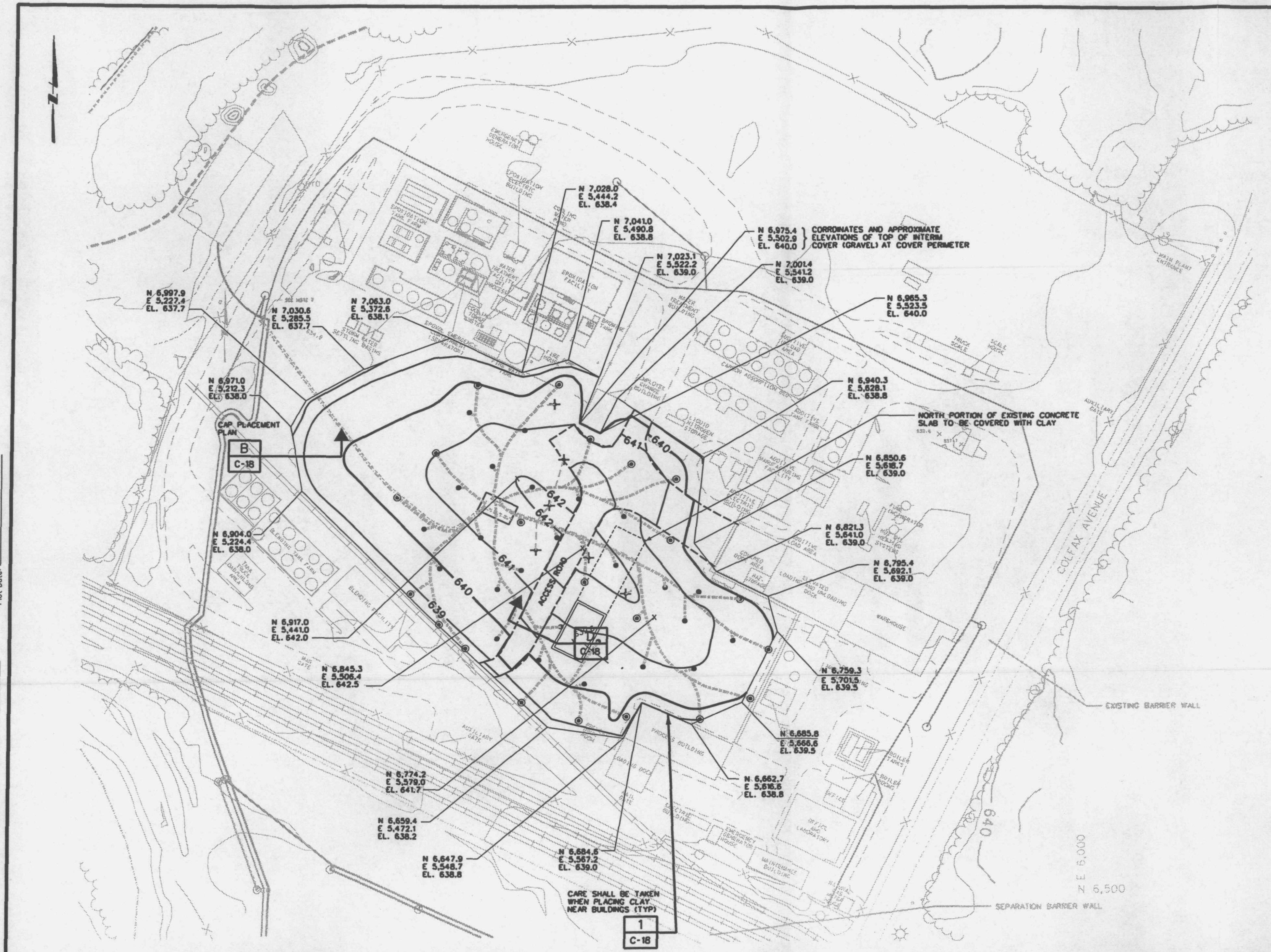
SUBMITTED BY
TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE
(COMPANY OFFICER) LICENSE NO. DATE

MONTGOMERY WATSON
Chicago, Illinois

ACS RD/RA GROUP
AMERICAN CHEMICAL SERVICE SUPERFUND SITE
GRIFFITH, INDIANA

100% REMEDIAL DESIGN
STILL BOTTOMS POND AREA
ISVE PLAN VIEW AND YARD PIPING

SHEET C-12



LEGEND:

–640–	TOP OF ASPHALT CONTOUR ELEVATION
●	ISVE WELL LOCATION
◉	DUAL PHASE WELL LOCATION
+	AIR SPARGE POINT

NOTES:

1. CONTOURS SHOWN FOR GRAPHICAL REPRESENTATION ONLY. COORDINATES WILL GOVERN GRADING AND SURVEY LAYOUT.
2. CLAY PLACEMENT NEAR BUILDINGS AND TANK PAD TO BE DONE SO AS NOT TO DAMAGE ANY EXISTING STRUCTURE OR FOUNDATION.

THOMAS A. BLAIR
REGISTERED
NO. 9600482
STATE OF INDIANA
PROFESSIONAL ENGINEER
expires 7/31/00
Tom Blair
signature
8/20/99
date

Plot Date: 99999date9999 99time99

File: Jr/1252/042/28/civ/acs28c10.dgn

Job No: MW Job #

REV	DATE	BY	DESCRIPTION	SCALE	WARNING		SUBMITTED BY				
				1" = 50'-0"	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED TAB DRAWN RBA CHECKED	TOM BLAIR (PROJECT MANAGER) IN-19600482 LICENSE NO. DATE (COMPANY OFFICER) LICENSE NO. DATE	MONTGOMERY WATSON Chicago, Illinois	ACS RD/RA GROUP AMERICAN CHEMICAL SERVICE SUPERFUND SITE GRIFFITH, INDIANA	100% REMEDIAL DESIGN STILL BOTTOMS POND AREA COVER TOP OF INTERIM CONTOURS	SHEET C-13

B

DESIGN MEMORANDUM

To: File

From: J. Smith, T. Hofmann, K. Lewis

Reference: ***In-situ*** **Soil Vapor Extraction (ISVE) System**
American Chemical Service NPL Site
Griffith, Indiana

Date: May 10, 1999

Project No.: 1252042.28350102

Purpose of ISVE System: The purpose of the ISVE systems at the ACS Site is volatile organic compound (VOC) reduction in source areas by extracting mobile VOCS, and, to some extent, semivolatile organic compounds (SVOCs) from below the ground surface.

ISVE areas:

Analytical results from soil samples collected during the Remedial Investigation (RI) and subsequent investigations were used to determine areal and vertical extent. In accordance with the Record of Decision (ROD), a VOC concentration of 10,000 ppm used to define the outer boundaries of buried waste. Three main areas of contamination were identified:

- Still Bottoms Pond Area (SBPA) (as a result of the solvent recovery waste disposal)
- Off-Site Containment Area (OFCA) (associated with the punctured drum and waste disposal)
- Kapica-Pazmey Area (KP) (relatively small, discrete areas of VOC contamination)

From above information, VOC mass was calculated for each area:

- SBPA ~ 3,600,00 lbs. at or above 10 feet
- OFCA ~ 1,500,00 lbs. at or above 15 feet
- KP ~ 600,000 lbs. at or above 15 feet

For additional information on mass calculations, refer to the 30% Remedial Design Document, Appendix A.

ISVE modeling:

References: EPA document 600/R-93/028. *Decision-Support Software for Soil Vapor Extraction Technology Application: Hyperventilate.*

U.S. EPA, 1991. *Soil Vapor Extraction Technology, Reference Handbook,* EPA/540/2-91/003, February 1991.

Using the mass information developed from the soil borings, ISVE modeling was performed to both determine if ISVE was a feasible remedy and develop preliminary design criteria. Hyperventilate® and BioSVE® (both recommended by U.S. EPA) were used for the ISVE modeling. The results of modeling indicated:

- Achievable flow rate
- Achievable rate of removal is comparable to the required rate of removal
- Acceptable radius of influence
- Number of wells

Flowrate (scfm) of a Single Well at a Well Vacuum

Area	1.75 Darcy	5.2 Darcy	10 Darcy
OFCA[1]	19.11	56.77	109.17
SBPA[2]	5.19	15.42	29.65
KP[1]	19.11	54.59	109.17

*scfm = Standard cubic feet per minute

[1] OFCA and KP area maximum vacuum will be at 120 inches of water based on 10 feet of screen.

[2] SBPA area maximum vacuum will be at 60 inches of water based on 5 feet of screen.

For more information on the results of ISVE modeling, refer to the 30% Remedial Design Document, Appendix B.

Design Considerations (refer to 95% RD for a detailed discussion)

- ISVE effectiveness around buried debris and waste
- Free-phase product
- Smearing
- Short-circuiting

General Description of ISVE Design

For the SBPA:

- Shallow water table, shallow and shorter screens
- Dewatered to specific level prior to ISVE operation
- Added dewater/dual extraction wells to aid in dewatering
- Wells and yard piping installed as full-scale

- Final ISVE design and operation after dewatered and after OFCA/KP operation for approximately 18 months to prevent over-design and over-capacity of the off-gas treatment system
- ACS operations will continue during ISVE operation. ISVE system designed around operations

For OFCA/KP:

- Deeper water table (at 15 feet or greater)
- No need to dewater before ISVE operation
- Will dewater to drop water table 5 feet to reach source
- No dual extraction – only ISVE wells
- Will initiate operation with one blower and one catalytic oxidation unit and operate for 18 months to obtain full-scale operation data to design the final system

Number of wells in each area:

Reference: P.C. Johnson, C.C. Stanley, M.W. Kemblowski, D.L. Byers, and J.D. Colthart. *Practical Approach to the Design, Operation, and Monitoring of In-Situ Soil-Venting Systems.* Groundwater Monitoring, Spring, 1990, pp. 159-178.

The number of ISVE wells to be installed in each area was determined by calculating the Radius of Influence (ROI). In this design, the ROI may be defined as the radius of the area around each ISVE well where 10% of the vacuum of the extraction well can be achieved. The actual ROI during operation will be the area around the ISVE well where a vacuum is detectable and where vapor can be extracted. The calculation to estimate ROI uses the hydraulic conductivity, specific vacuum, and achievable flowrates from an ISVE well. For the calculations, hydraulic conductivity was estimated based on an in-situ slug test performed on undisturbed soil during the RI and the possible vacuums and flowrate estimated during modeling. Results indicated that the ROI ranged in values from 40 feet to 75 feet. Due to the heterogeneous nature of the waste and the void spaces present in the debris, the actual ROI expected to vary greatly. Therefore, to be conservative, a 30-ft ROI (60-ft well spacing) was used for the design. The design utilized this value to minimize the uncertainty regarding vapor capture in the ISVE well fields. In addition, the design ROIs of individual ISVE wells were overlapped to ensure that the entire area would be influenced by the ISVE system.

Based on the conservative ROI and the areal extent of contamination, the following is a breakdown of the number of ISVE wells in each area:

- 12 wells in KP
- 30 wells in OFCA
- 46 wells in SBPA (Because of Site structures, fewer of wells will be installed than original calculated.) Of the 46 wells to be installed in the SBPA, 21 wells will be dual extraction wells, while 25 wells will be ISVE-only wells. The total number of ISVE-only wells to be installed is equal to 67.

General ISVE well construction details

- 10 inch boreholes.
- 4-inch stainless steel screens with lengths that are 5, 10 or 15 feet.
- 4-inch polyvinyl chloride (PVC) or stainless steel riser pipes.
- Stainless steel and PVC used for resistance to chemical attack, rigidity, and availability.
- Stainless steel well used for additional chemical resistance.
- 5 feet minimum solid casing below the interim clay covers.
- Stick-up wells on the OFCA, KPA and most of the SBPA. Only the SBPA wells will have locking protective casings.
- Flush mounted wells will be installed within in traffic areas of the SBPA.
- Wells will terminate near or several feet into the dewatered groundwater levels.
- High-density polyethylene (HDPE) conveyance lines.

Wells will be installed so that the screened portion of the well is within the estimated vertical distribution of contaminants in the area. The screens will be at least 5 feet below the top of the interim cap to avoid short-circuiting of atmospheric air through the ground surface. Each well head will have a removable cover and each vent line will have a sample and monitoring port located within the blower shed. This design allows accessibility for vacuum and water level measurements at the wellheads and vacuum and vapor sample collection in the blower shed, if necessary.

Dual phase extraction well design:

- Installed in SBPA only
- 12 inch boreholes.
- 6-inch stainless steel screens with lengths that are 15, 20 or 25 feet.
- 6-inch PVC riser pipes.
- 5 feet minimum solid casing below the interim (clay) covers.
- Flush mounted wells installed in traffic-loaded vaults.
- Well will terminate at or near the subsurface clay till.
- 21 wells (18 @ perimeter, 3 in central portion).
- HDPE conveyance lines.

During dewatering activities, every other well on 'outside ring' and three 'inside' wells will operate. (12 wells initially operational) This will:

- Prevent drawdown overlap
- If a well clogs up, the pump may be pulled and placed in a nearby 'empty' dewatering well
- If more dewatering is necessary, additional pumps may be installed quickly

The dual phase wells, wellhead fittings, and piping will be installed in below-grade load-bearing vaults 3 feet by 3 feet deep. Each well will be installed with a pump air supply line, 2-inch access hole for water level measurement, a pump exhaust line, a pump liquid discharge line, a sample and monitoring port, and SVE lateral conveyance line. The liquid conveyance line will convey groundwater to groundwater treatment plant. See the dewatering information in Appendix C of this design document for calculations.

Piping Layout and Shed Placement

The overall design criteria used to design the piping layout and shed placement was to minimize potential blinding of pipe by condensate collection. Therefore, to minimize condensate collection, the blower shed was placed on a high point and the pipes were, where applicable, placed running uphill to the blower shed. In this configuration, any condensate collected would gravity flow downhill and drain back into the wells.

Because the conveyance lines are HDPE, the pipe is relatively flexible. Because of this flexibility, the condensate lines are shown as curves rather than straight lines in the design drawings. The conveyance lines shown in the design drawings are a representation and may be adjusted in the field.

One blower shed will be constructed in the SBPA. Using the grading plan for the on-site cap, the blower shed was placed at the highest elevation on the grading plan. Using the grading plan, the ISVE conveyance piping layout was designed so that the lines run uphill back to the blower shed.

One blower shed will be constructed for OFCA and KP. One blower shed is feasible for both areas to reduce redundancy because only 12 ISVE wells will be installed in the KP (small system).

The ISVE yard piping will be installed through the interim cap onto the approximate original ground surface. Therefore, utilizing the original ground surface contour map, the blower shed was placed on top of a high point between the OFCA and the KP. Similar to the design in the SBPA, the conveyance lines were placed so that a majority of the piping ran uphill to the blower shed. For the KP, several conveyance pipes run downhill to the blower shed. However, because the groundwater table in the KP is deeper than the OFCA, less, if any, condensate is expected to be generated. Any condensate that is collected will be removed from the system at the knock-out tank inside the blower building prior to the blower.

All gas conveyance lines run individually back to their respective blower shed. These conveyance lines are to lie in the same trench. The pipes will come up through the blower shed's floor and be manifolded together inside the shed. This allows ease of operation for the system operator (will have access to all wells inside building inside of having to make trips out to individual wells in the well field).

Pipe Materials and Loading

HDPE was selected because of its chemical resistance to a multitude of chemical mixtures as seen in its use in landfills. Because of its flexibility, HDPE will be easier to install than PVC or steel. HDPE piping was checked for loading under interim cap conditions to determine what pipe thickness is required. The interim cap (12 inches) was used because it is the smallest amount of cover present during operation. In addition, the interim cover will be in place for 12 to 18 months while the ISVE system is optimized.

The design loading used was an AASHTO-H20 truck loading. Also, unconstrained pipe wall buckling also considered and calculated. Based on the design calculations, SDR-11 HDPE was chosen.

ISVE Mechanical Discussion

Design and installation of the ISVE system will be implemented in stages. The initial OFCA and K-P ISVE system will consist of a single blower and off-gas treatment system. Following start-up of the OFCA and K-P initial systems, the system will be upgraded, as necessary, to operate at full-scale. The SBPA system will be similarly started-up in phases.

ISVE Blower

The 40 hp centrifugal blower to be installed in the OFCA shed as part of the initial system was selected to deliver 1,000 standard cubic feet per minute (scfm) to the off-gas treatment system at an applied vacuum of 60 inches water at the extraction wells. Assumptions made in sizing the ISVE blower are as follows:

- A vacuum of 60 inches water will be applied at the extraction well farthest from the blower.
- The extraction wells will have 10 feet of available screen. Assuming 10 cubic feet per minute (cfm) from each foot of available screen, 100 cfm is expected from each well.
- The blower will deliver 1,000 scfm to the catalytic oxidizer.
- A pressure loss of 36 inches of water was calculated on the vacuum side of the blower, from the extraction well farthest from the blower. A pressure loss of 27 inches of water was calculated on the discharge side of the blower. Calculations are attached.
- Pipe sizes were selected to minimize pressure losses in the ISVE system.

Condensate Pump

The condensate pump to be installed in the Off-Site Containment Area shed as part of the initial system was selected to deliver 17 gallons per minute (gpm) to the groundwater treatment plant. Assumptions made in sizing the condensate pump are as follows:

- The groundwater treatment plant can receive a maximum of 17 gpm from the Off-Site Containment Area ISVE system.
- A head loss of 40 feet of water was calculated through the condensate transfer system, based on a flow rate of 20 gpm. Calculations are attached.
- A low-shear pump such as a progressing cavity or air-operated diaphragm pump will be installed to minimize emulsification of possible free product.

Catalytic Oxidizer

A catalytic oxidizer was selected to treat 1,000 cfm soil vapor delivered by the Off-Site Containment Area ISVE blower. Assumptions made in sizing the catalytic oxidizer are as follows:

- Initial soil vapor concentrations in the Off-Site Containment Area were estimated based on vapor/soil equilibrium conditions. Specific VOCs were assumed to be 10 or 20% of the maximum, equilibrium concentration. Calculations are attached.
- A 1,000 scfm catalytic oxidizer can process up to approximately 40 pounds VOCs per hour, based on hydrogen chloride exposure and heat generation in the catalyst. A 1,000 scfm unit was selected to enable treatment of a reasonable quantity of extracted soil vapor.

Scrubber

A 1,000 scfm scrubber was selected to remove hydrochloric acid generated during oxidation of chlorinated compounds in the catalytic oxidizer. Accumulated hydrochloric acid will be neutralized with sodium hydroxide, creating up to 100 gallons per hour of brine solution. Assumptions regarding brine generation are as follows:

- Brine generation was calculated based on the stoichiometric relationship with the chlorinated VOC concentration in the soil vapor. Calculations are attached.
- Brine will be disposed through the city sanitary sewer system.

Air Sparging:

References: U.S. Arm Corp of Engineers, 1997. *In-Situ Air Sparging, Engineering Manual EM 1110-1-4005*, September 15, 1997.

Wisconsin DNR, 1993. *Guidance for Design, Installation and Operation of In-Situ Air Sparge Systems*. Publication SW186-93. Wisconsin Department of Natural Resources, Madison, WI.

Air sparging will be used to address areas of deeper VOC contamination below the elevation of the lowered water table. Several deep samples from borings conducted during the RI showed elevated levels of VOCs in the SBPA and the OFCA (Figure 11 of the 30% RD). Direct push sparge points will be advanced near these sample locations to a depth near the top of the subsurface clay. The design of these sparge points was conducted using United States Army Corps of Engineers (USACE) and Wisconsin Department of Natural Resources (WDNR) guidance and will consist of:

- 1-inch stainless steel screens with 2-foot lengths.
- 1-inch stainless steel riser pipes below the dewatered water level and PVC risers above the dewatered water level.
- Stick-up points on the OFCA and most of the SBPA. Only the SBPA will have locking protective casings.
- Flush mounted points will be installed within traffic areas of the SBPA.
- Points will terminate at or near the subsurface clay till.
- 6 sparge points in the SBPA and 3 sparge points in the OFCA.
- 2-inch HDPE pressurized air-lines to each sparge point.
- Point will be installed by direct-push technology. No filter pack is needed because of the sandy geology and porous refuse.
- A dedicated compressor/blower will be installed in each blower shed to provide the necessary pressure and flow for operation of the sparge points.
- A maximum pressure of 16.8 psi was calculated for both areas and an overall supplied pressure is 17.7 to 17.8 psi.

Schedule and Process Startup

ISVE will be implemented first at the OFCA and K-P Areas because the vadose zone is already thick enough at these locations to allow vapor extraction. However, the groundwater level in the OFCA and K-P Area will eventually be lowered in order to more efficiently ISVE in these areas. After the water elevation in the OFCA and K-P Areas is dropped to the target level, dewatering of the SBPA will be initiated. The ISVE system will not be operated at the SBPA until the water level has been lowered approximately 5 feet, because the shallow depth of groundwater in this area would limit vapor recovery by the ISVE system.

Start-up of the ISVE system at the OFCA, K-P, and SBPA will be conducted in phases because of the uncertainties regarding subsurface conditions and the nature of the ISVE mass transfer process. All vapor extraction wells and conveyance piping will be installed as shown on the design drawings. The overall concept of the phased start-up is:

- Initially start operation with a subset of extraction wells,
- Observe performance over an initial period, and
- Use the preliminary results to adjust the design of the full-scale mechanical and vapor treatment system.

This will allow flexibility to adjust system operation and provide the basis to design subsequent phases to optimize overall operation for the steady state or the diffusive regime. By installing the interim cover first, and then conducting phase start-up of the ISVE system, prior to installing the final covers, changes necessary to the ISVE piping or wells can be accommodated without compromising the final cover on the sites. Specific features that will be provided by the phased implementation schedule include the following:

- Control of initial operation for uncertain site conditions.
- Capability to change operating configurations to deal with differences in localized conditions.
- Flexibility to modify system configuration and operation as conditions change over time (i.e., from advective to diffusive removal).
- Avoidance of treatment capacity exceedances.
- Optimization of energy efficiency by avoiding oversizing the system to meet initial conditions.
- Reduce cost and minimize pollution by minimizing use of supplemental fuel to maintain contaminant destruction.

The phased start-up will be conducted in lieu of a small-scale pilot study. Because the Site is a heterogeneous landfill, a pilot study would only provide information specific to the limited area influenced by the study. Information obtained from a phased start-up will be more comprehensive than the information provided by a small-scale pilot test because it:

- Will be utilizing the full-scale well configuration,
- Will have a longer duration, and
- Will cover a wider area.

It will also be more cost-effective because the equipment sizing will be based on long-term operation during diffusive extraction, instead of short-term start-up operation.

It is anticipated that operation of the ISVE system will be conducted in seven phases:

1) **0 to 6 months:** Operation of the initial 1,000 scfm ISVE system at the OFCA/K-P Area.
2) **6 to 12 months:** Evaluation and design of the full-size ISVE system to address the entire OFCA/K-P Area.

3) **12 to 18 months:** Installation and operation of the full-size ISVE system at the OFCA/K-P Area.
4) **18 to 24 months:** Operation of the initial 1,000 scfm ISVE system at the SBPA.
5) **24 to 30 months:** Evaluation and design of system modifications to optimize operation of the full-size ISVE system at the SBPA (while still operating the OFCA/K-P Area).
6) **30 months to Cycle Phase:** Installation and operation of the full-size ISVE system at the SBPA (while still operating the OFCA/K-P ISVE System).
7) **Cycle Phase:** Operation of the ISVE system in on/off cycles, once mass removal becomes limited by constituent diffusion rates.

JMS/jms/KAL/kal/TLH/RAA
J:\1252\042\28\Documents\125204228a152.doc
1252042.28350102

MONTGOMERY WATSON

BY Kal DATE 3/10/99 CLIENT ACS SHEET 1 OF 3
CHKD. BY ___ DESCRIPTION ISVE System - Scrubber effluent JOB NO. ___

Calculation volume of brine generated:

assumptions: worst case vapor concentration, off-site Containment area, calculated based on Constituent vapor pressures and mass fraction in soil, X% of value obtained

→ loading to oxidizer limited to generation of 5000 ppmv HCl
1,000 scfm system

calculations were conducted via attached spreadsheet and are detailed below

vapor concentration = 60,930 ppmv VOCs
equivalent HCl concentration = 98,170 ppm

based on limit of 5000 ppmv HCl, can only treat 50 scfm from wells

(50 scfm)(98,170 ppmv HCl) + (950 scfm)(0 ppmv) = (X ppmv HCl)(1000 scf

$\boxed{X = 4909 \text{ ppmv HCl}}$ - equivalent HCl concentration in vapor to oxidizer

Example calculations for 1,1,1-TCA @ vapor concentration 16,960 ppmv

molar loading from wells (50 scfm) from conditions

P = 14.7 psi
V = 50 scfm
T = 530 R
R = 10.73 $\frac{\text{psi}\cdot ft^3}{\text{lb-mol R}}$

70°F

PV = nRT

$(14.7\text{psi})(50\ \frac{ft^3}{min}) = n\left(10.73\ \frac{\text{psi}\ ft^3}{\text{lb-mol R}}\right)(530\ R)$

$\boxed{n = 0.13\ \frac{\text{lb-mol}}{\text{min}} = 7.75\ \frac{\text{lb-mol}}{\text{hr}}}$

B = ...

the ppmv were calculated based on vacuum conditions and 10°C

ISVE CALC 8

MONTGOMERY WATSON

BY JAL DATE 3/10/99 CLIENT ACS SHEET 2 OF 3
CHKD. BY [illegible] DESCRIPTION ISVE System - scrubber effluent JOB NO.

constituent loading:

ppmv = ppm, molar basis

$$7.75 \frac{lb\text{-}mol}{hr} \times \frac{16,960 \text{ mol } 1,1,1\text{-TCA}}{10^6 \text{ mol}} = \boxed{0.13 \frac{lb\text{-}mol}{hr} \ 1,1,1\text{-TCA}}$$

HCl loading to scrubber:

$$0.13 \text{ lb-mol} \frac{1,1,1\text{-TCA}}{hr} \times \frac{3 \text{ mol HCl}}{\text{mol } 1,1,1\text{-TCA}} = \boxed{0.39 \text{ lb-mol} \frac{HCl}{hr}}$$

Total HCl loading to scrubber: $\boxed{0.7613 \frac{lb\text{-}mol}{hr}}$ - from spreadsheet

<u>Scrubber Effluent</u>:

$$0.7613 \text{ lb-mol} \frac{HCl}{hr} \times \frac{1 \text{ lb-mol NaCl}}{\text{lb-mol HCl}} \times \frac{58.44 \text{ lb NaCl}}{\text{lb-mol}} = \boxed{44.49 \text{ lb} \frac{NaCl}{hr}}$$

o.k. <u>5 wt %</u> NaCl maintained in scrubber

$$44.49 \text{ lb} \frac{NaCl}{hr} = (0.05) \left(x \text{ lb} \frac{brine}{hr} \right)$$

$$x = 889.80 \text{ lb} \frac{brine}{hr}$$

specific gravity, 5% brine soln. = <u>1.03</u> ← This should be close to 1.05 but o.k.

$$889.80 \text{ lb} \frac{brine}{hr} \times \frac{gal}{(8.33)(1.03) lb} = \boxed{104 \text{ gal} \frac{brine}{hr}}$$ ✓

operating 2 oxidizers, assuming similar influent concentrations:

total scrubber effluent = $\boxed{208 \frac{gal}{hr}}$

ISVE CALC 9

MONTGOMERY WATSON

BY KAL DATE 3/10/99 CLIENT ACS SHEET 3 OF 3
CHKD. BY DESCRIPTION ISVE system scrubber effluent JOB NO.

Calculation of NaOH required:

$$0.7613 \frac{\text{lb-mol HCl}}{\text{hr}} \times \frac{1 \text{ lb-mol NaOH}}{\text{lb-mol HCl}} = \boxed{0.7613 \frac{\text{lb-mol NaOH}}{\text{hr}}}$$

$$0.7613 \frac{\text{lb-mol NaOH}}{\text{hr}} \times \frac{40 \text{ lb NaOH}}{\text{lb-mol}} = \boxed{30.45 \frac{\text{lb NaOH}}{\text{hr}}}$$

NaOH sold as 50% by weight solution

$$30.45 \frac{\text{lb NaOH}}{\text{hr}} \times \frac{1}{0.5} = 60.90 \frac{\text{lb NaOH soln}}{\text{hr}}$$

$$60.90 \frac{\text{lb NaOH soln}}{\text{hr}} \times \frac{\text{gal}}{12.6 \text{ lb}} \times \frac{24 \text{ hr}}{\text{day}} \times \frac{7 \text{ day}}{\text{wk}} \times 4 \text{ wk} = \boxed{3248 \frac{\text{gal}}{\text{month}}}$$ - one scrubber

Calculation of volume brine generated and NaOH required, based on low estimated constituent concentrations done on spreadsheet

For estimated constituent concentrations two orders of magnitude less than worst case concentrations

[illegible] 2nd spreadsheet also.

MONTGOMERY WATSON

BY Kal DATE 3/30/99 CLIENT AcS SHEET 1 OF 3
CHKD. BY NWC 5/7/99 DESCRIPTION Pressure Loss - SVE Blower System JOB NO.

Off-site / KP area - vacuum end

- target vacuum at wellhead = 60 inches water @ high side. O.K.
- 10 ft available screen; rule of thumb - 10 acfm / ft available screen
  ∴ assume 100 acfm from each well
- calculate pressure loss using the following equation: (from Mechanical Engineering Reference Manual, 8th edition Michael R. Lindeburg, PE, p F6)

$$P_{loss} = (3.9\times10^{-9})\, V^{2.43} \frac{L}{Q^{0.61}}$$ ✓ O.K.

P_{loss} - pressure loss, inches water
L : length, ft
V : velocity, ft/min
Q : flowrate, cfm

Longest pipe run is 364 feet in off-site / KP area. To reduce pressure loss, assume 3" diameter pipe

$$V = 100 \frac{ft^3}{min} \times \frac{1}{\pi\left(\frac{3}{2\cdot12}\right)^2 ft^2}$$

$$\boxed{V = 2037 \frac{ft}{min}}$$ ← O.K

$$P_{loss} = (3.9\times10^{-9})\left(2037\frac{ft}{min}\right)^{2.43} \frac{(\cancel{3??}\ 364\ ft)}{\left(100\frac{ft^3}{min}\right)^{0.61}}$$

$\boxed{P_{loss} = \cancel{8.39}\ 9.40 \text{ inches water}}$

with safety factor of 20%: $P_{loss} = (\cancel{8.39})(1.2)$

$\boxed{P_{loss} = \cancel{10.07}\ 11.28 \text{ inches water}}$ ✓

PART 2: Duct Design

1 FRICTION LOSSES IN DUCTS

Friction losses can be calculated from the Moody equation.

Moody Equation

$$p_{loss} = \frac{fLp_v}{D} \approx (.0270)\frac{L}{(d)^{1.22}}\left(\frac{v}{1000}\right)^{1.82} \qquad 5.27$$

$$\approx (3.9\ \mathrm{EE}-9)(v)^{2.42}\frac{L}{(Q)^{.61}} \qquad 5.28$$

In practice, equation 5.27 seldom is used. Figure 5.4 is based on equation 5.27 with a value of specific roughness equal to .0005, a standard density of .075 lbm/ft³, clean round galvanized metal ductwork, and approximately 40 joints per 100 feet. The chart can be used for temperatures between 50 °F and 90 °F. For operation outside this range, the pressure loss should be corrected with equation 5.29. K_e is usually taken as 1.0.

ε

T

$$(p_{loss})_{actual} = p_{loss,\ fig.\ 5.4} \times \frac{K_e}{K_d} \qquad 5.29$$

if parameters differ from above

Figure 5.4 is for use with standard round, galvanized ducts. Multiply the friction losses by the factors in table 5.2 for other materials. (Actual values are velocity dependent. Tables and charts exist for this purpose.)

Table 5.2
Multiplicative Factors for Non-Standard Ducts

correct Fig 5.4 for not round steel ducts

Smooth ducts—no joints	.8-.95
Smooth concrete	1.1–1.4
Rough concrete/good brick	1.2–1.8

The *equivalent diameter* of a rectangular air duct with dimensions a and b, and aspect ratio less than 8.0 is

use for not round

$$D_e = 1.3\frac{(ab)^{.625}}{(a+b)^{.25}} \qquad 5.30$$

A round duct with diameter D_e will have the same friction and capacity as a square duct with dimensions a and b. Figure 5.4 can be used with D_e and flow rate to find the friction loss.

If the aspect ratio of the rectangular duct is known, a round duct can be converted to a rectangular duct of equal friction. The *aspect ratio*, which should be kept below 8.0 for ease of manufacturing, is

$$R = \frac{\text{longest side}}{\text{short side}} \qquad 5.31$$

Aspect ratio

The short side, a, is given by equation 5.32.

$$a = \frac{D_e(R+1)^{\frac{1}{4}}}{1.3(R)^{.625}} \qquad 5.32$$

Example 5.6

2000 cfm of air flow in a 13″ diameter duct. What is the velocity and the friction loss per 100 feet of duct?

Although the $Q = Av$ relationship could be used to find the velocity, it is expedient to use figure 5.4. By locating the intersection of the 2000 cfm and the 13″ lines, the velocity is found to be 2200 fpm.

Dropping straight down from the intersection point to the horizontal scale gives the friction loss as approximately .5″ w.g. per 100 feet.

Example 5.7

What size duct is required to carry 2000 cfm at 1600 fpm?

Figure 5.4 shows that a 15″ diameter duct is required.[4] The friction loss is approximately 0.23″ w.g. per 100 feet.

2 MINOR AND DYNAMIC LOSSES

Minor losses are fairly independent of air velocity and roughness. In the *loss coefficient method*, the losses are calculated as a percentage of the velocity pressure.

Minor Losses ΔP_v

$$p = c\left(\frac{v}{4005}\right)^2 = cp_v \qquad 5.33$$

Typical values of c are given in table 5.3. Subscripts 1 and 2 refer to upstream and downstream, respectively. The coefficient c always should be used with the velocity at the point corresponding to its subscript.

The *equivalent length method* also can be used to calculate the friction of a bend or an elbow. As with equivalent lengths used in liquid flow problems, each obstruction produces a frictional loss equivalent to some length of duct. These lengths are given in multiples of the duct diameter in table 5.3.

[4]Any size duct can be manufactured. However, there are standard sizes available, and these sizes should be chosen to minimize cost. Generally, every whole-inch size up to 30″ diameter is available, although some odd-number sizes may be premium-priced. After 30″, sizes are available in 2″ increments.

Kapica Pazmey Area 2"

Pipe ID	Pipe size (in)	Pipe Length (ft)	Appurtenances
SVE-01 to Blower Building 1	2	364	2 90-elbows - Assume similar to still bottoms Area:
SVE-02 to Blower Building 1	2	334	2 90-elbows 4" x 4" tee
SVE-03 to Blower Building 1	2	284	2 90-elbows 4" x 3" reducer
SVE-04 to Blower Building 1	2	273	2 90-elbows
SVE-05 to Blower Building 1	2	357	2 90-elbows
SVE-06 to Blower Building 1	2	333	2 90-elbows
SVE-07 to Blower Building 1	2	304	2 90-elbows
SVE-08 to Blower Building 1	2	282	2 90-elbows
SVE-00 to Blower Building 1	2	313	2 90-elbows
SVE-10 to Blower Building 1	2	352	2 90-elbows
SVE-11 to Blower Building 1	2	332	2 90-elbows
SVE-12 to Blower Building 1	2	255	2 90-elbows

Pipe Lengths and Appurtances
ACS NPL Site

3"

Off-Site Containment Area

Pipe ID	Pipe size (in)	Pipe Length (ft)	Appurtenances
SVE-13 to Blower Building	2	20	2 90-elbows
SVE-14 to Blower Building	2	7	2 90-elbows
SVE-15 to Blower Building	2	20	2 90-elbows
SVE-16 to Blower Building	2	59	2 90-elbows
SVE-17 to Blower Building	2	124	2 90-elbows
SVE-18 to Blower Building	2	129	2 90-elbows
SVE-19 to Blower Building	2	170	2 90-elbows
SVE-20 to Blower Building	2	202	2 90-elbows
SVE-21 to Blower Building	2	228	2 90-elbows
SVE-22 to Blower Building	2	57	2 90-elbows
SVE-23 to Blower Building	2	97	2 90-elbows
SVE-24 to Blower Building	2	106	2 90-elbows
SVE-25 to Blower Building	2	145	2 90-elbows
SVE-26 to Blower Building	2	191	2 90-elbows
SVE-27 to Blower Building	2	193	2 90-elbows
SVE-28 to Blower Building	2	233	2 90-elbows
SVE-29 to Blower Building	2	253	2 90-elbows
SVE-30 to Blower Building	2	52	2 90-elbows
SVE-31 to Blower Building	2	52	2 90-elbows
SVE-32 to Blower Building	2	87	2 90-elbows
SVE-33 to Blower Building	2	110	2 90-elbows
SVE-34 to Blower Building	2	120	2 90-elbows
SVE-35 to Blower Building	2	155	2 90-elbows
SVE-36 to Blower Building	2	167	2 90-elbows
SVE-37 to Blower Building	2	197	2 90-elbows
SVE-38 to Blower Building	2	225	2 90-elbows
SVE-39 to Blower Building	2	245	2 90-elbows
SVE-40 to Blower Building	2	274	2 90-elbows
SVE-41 to Blower Building	2	276	2 90-elbows
SVE-42 to Blower Building	2	306	2 90-elbows
To GWTP	~~6~~	1250	

8"

MONTGOMERY WATSON

BY HR DATE 4/5/99 CLIENT ACS SHEET 2 OF 3
CHKD. BY NWC DESCRIPTION Pressure Loss SVE Blower System JOB NO.

- Blower sized for 1000 scfm. Vacuum will be highest at blower influent ∴ volume of air will be higher. Assume pressure loss through SVE extraction piping is 35 in H_2O. Calculate flow at blower, use this flow for calculation in 6" header pipe.

$$1\,atm \times \frac{33.9\,ft\,H_2O}{atm} \times \frac{12\,in}{ft} = 407\,in\,H_2O \quad ✓$$

vacuum at blower = 60 (vac at wellhead) + 35 (pressure loss in piping) = 95 in H

$$PV = nRT$$

$$n_1RT_1 = n_2RT_2 \quad \text{(assume air temp} \sim 70°F)$$

$$\therefore P_1V_1 = P_2V_2$$

$$(407\,in\,H_2O)(1000\,scfm) = [(407-95)\,in\,H_2O]\,V_2$$

$$\boxed{V_2 = 1300\,acfm}$$

just scfm will be ok.

A summary of the pressure loss for the overall SVE system vacuum side is provided in the attached spreadsheet.

- Confirmation, turbulent flow (requirement, Table 3.9 - equivalent lengths).

turbulent flow when $N_{Re} > 2000$

$$N_{Re} = \frac{Dv}{\nu}$$

standard conditions

D = diameter, ft
v = velocity, ft/s
ν = kinematic viscosity, ft^2/sec = $16.0 \times 10^{-5}\,ft^2/sec$ @ 68°F

please also [illegible]

in 3" pipe, v = 34 ft/sec (see spreadsheet)

$$N_{Re} = \frac{(\frac{3}{12}ft)(34\,ft/sec)}{16.0\times10^{-5}\,ft^2/sec} \quad ; \boxed{N_{Re} = 53{,}125} \quad \therefore \text{turbulent}$$

in 6" pipe, v = 110 ft/sec (see spreadsheet)

$$N_{Re} = \frac{(\frac{6}{12}ft)(110\,ft/sec)}{16.0\times10^{-5}\,ft^2/sec} \quad ; \boxed{N_{Re} = 343{,}750} \quad \therefore \text{turbulent}$$

EN 1S (10/78)

SVE Pressure Loss, Vacuum Side of Blower
Off-Site/KP as

Pipe or Fitting	Flow Rate (acfm)	Number of fitting	Eq. Length per fitting (1) (ft)	Length of Pipe or Eq. Length of Fittings (ft)	Diameter of Pipe or Fitting (inches)	Velocity (fpm - act)	Velocity (fps - act)	Pressure Loss (2) (inches water)	Cummulative Pressure Loss (inches water)
4" riser pipe	100	-	-	20	4	1146	19	0.15	[illegible]
3" pipe from well field	100	-	-	364	3	2037	34	11.28	[illegible]
6" header pipe to blower	1300	-	-	77	6	6621	110	8.75	[illegible]
4" x 4" tee	100	1	21.0	21	4	1146	19	0.16	[illegible]
4" x 3" reducer	100	-	-	-	3	2037	34	0.05	[illegible]
3" standard 90 elbow	100	2	10.8	22	3	2037	34	0.67	[illegible]
6" standard 90 elbow	1300	7	8.9	62	6	6621	110	7.08	[illegible]
6" tee	1300	2	18.0	36	6	6621	110	4.09	[illegible]
3" ball valve	100	1	***2.0***	2	3	2037	34	0.06	[illegible]
6" butterfly valve	1300	1	***3.20***	3	6	6621	110	0.36	[illegible]
knockout tank	1300							***3.60***	[illegible]

should arrange this in proper sequence.

too high for 6" line, it will be on the high side. If you use 1000 scfm, but O.K.

Velocity Equation v (fpm) = Q - flow rate (scfm) / 3.14159 x (d - diameter (in) / 24) ^ 2

Pressure Loss Ploss (inches water) = 3.9EE-9 * v - velocity (fpm) ^ 2.43 * L - length (ft) * Q - flowrate (scfm) ^ 0.61

Pressure Loss, reducer (3) Ploss (inches water) = c * (v (fpm) / 4005)^2

(1) from Mechanical Engineering Reference Manual, 8th Edition; Michael R. Lindeburg, P.E., p 3-21
(2) Includes 20% safety factor
(3) from Mechanical Engineering Reference Manual, 8th Edition; Michael R. Lindeburg, P.E., p 5-6; from p 5-8, A(2)/A(1) = 0.6, c = 0.16

Cells with italicized bold print have attached comment.

KAL/kal/BL
J:\1252\042\280101\125204228\002.xls

Cell: E9
Comment: kalewis:
17 feet vertical
60 feet horizontal

Cell: D15
Comment: kalewis:
Assume equal to gate valve

Cell: D16
Comment: kalewis:
Assume equal to gate valve; From Perry's Handbook, K value for butterfly valve, 5 deg angle = 0.24; K value for open gate valve = 0.17

Cell: I17
Comment: kalewis:
from Catalytic Combustion

The relative roughness is

$$\frac{\epsilon}{D} = \frac{.0002}{.3355} = .0006$$

From the Moody friction factor chart, $f = .0195$.

From equation 3.71.

$$h_f = \frac{(.0195)(1000)(7.56)^2}{(2)(.3355)(32.2)} = 51.6 \text{ ft}$$

Example 3.20

Repeat example 3.19 using the Hazen-Williams formula. Assume $C = 100$.

Using equation 3.73.

$$h_f = \frac{(3.022)(7.56)^{1.85}(1000)}{(100)^{1.85}(.3355)^{1.165}} = 90.8 \text{ ft}$$

Using equation 3.74.

$$h_f = (10.44)(1000)\frac{(300)^{1.85}}{(100)^{1.85}(4.026)^{4.8655}} = 90.9 \text{ ft}$$

3 MINOR LOSSES

In addition to the head loss caused by friction between the fluid and the pipe wall, losses also are caused by obstructions in the line, changes in direction, and changes in flow area. These losses are named *minor losses* because they are much smaller in magnitude than the h_f term. Two methods are used to determine these losses: the method of equivalent lengths and the method of loss coefficients.

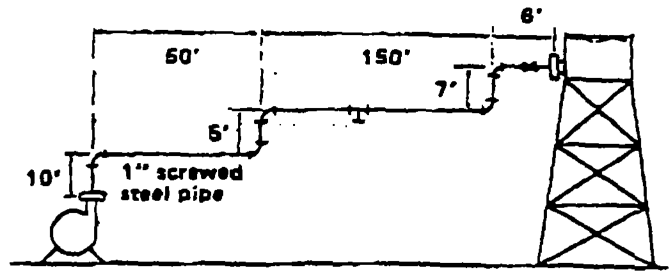
The method of *equivalent lengths* uses a table to convert each valve and fitting into an equivalent length of straight pipe. This length is added to the actual pipeline length and substituted into the Darcy equation for L_e.

$$h_f = \frac{fL_e v^2}{2Dg_c} \qquad 3.76$$

Use equivalent lengths for components + fittings.

Example 3.21

Using table 3.9, determine the equivalent length of the piping network shown.



The line consists of:

1 gate valve	.84
5 90° standard elbows	5.2×5
1 tee run	3.2
straight pipe	228
L_e =	258 feet

The alternative is to use a loss coefficient, K. This loss coefficient, when multiplied by the velocity head, will give the head loss in feet. This method must be used to find exit and entrance losses.

$$h_f = K\frac{v^2}{2g_c} \qquad 3.77$$

Use loss coeffic: for exit and entrance losses.

Table 3.9
Typical Equivalent Lengths of Schedule 40 Straight Pipe For Steel Fittings and Valves

(For any fluid in turbulent flow)

Equivalent Length, ft

Fitting Type	Pipe Size* 1"	2"	3'	4"	6"	(flanged pipe) 8"
Standard Radius 90° Elbow	5.2	8.5	10.8	13.0	8.9	12.0
Long Radius 90° Elbow	2.7	3.6		4.6	5.7	7.0
Regular 45° Elbow	1.3	2.7		5.5	5.6	7.7
Tee, flow through line (run)	3.2	7.7		17.0	3.8	4.7
Tee, flow through stem	6.6	12.0	16.5	21.0	18.0	24.0
180° Return Bend	5.2	8.5		13.0	8.9	12.0
Globe Valve, open	29.0	54.0		110.0	190.0	260.0
Gate Valve, open	.84	1.5	2.0	2.5	3.2	3.2
Angle Valve, open	17.0	18.0		18.0	63.0	90.0
Swing Check Valve	11.0	19.0		38.0	63.0	90.0
Coupling or Union	.29	.45		.65	—	—

*Screwed pipe and fittings unless flanged indicated.

PART 2: Duct Design

1 FRICTION LOSSES IN DUCTS

Friction losses can be calculated from the Moody equation.

Equation

$$p_{loss} = \frac{fLp_v}{D} \approx (.0270)\frac{L}{(d)^{1.22}}\left(\frac{v}{1000}\right)^{1.82} \qquad 5.27$$

$$\approx (3.0\ \text{EE}-9)(v)^{2.43}\frac{L}{(Q)^{.61}} \qquad 5.28$$

In practice, equation 5.27 seldom is used. Figure 5.4 is based on equation 5.27 with a value of specific roughness ε equal to .0005, a standard density of .075 lbm/ft³, clean round galvanized metal ductwork, and approximately 40 joints per 100 feet. The chart can be used for temperatures between 50 °F and 90 °F. T For operation outside this range, the pressure loss should be corrected with equation 5.29. K_e is usually taken as 1.0.

$$(p_{loss})_{actual} = p_{loss,\,fig.\,5.4} \times \frac{K_e}{K_d} \qquad 5.29$$

if parameters differ from above

Figure 5.4 is for use with standard round, galvanized ducts. Multiply the friction losses by the factors in table 5.2 for other materials. (Actual values are velocity dependent. Tables and charts exist for this purpose.)

Table 5.2
Multiplicative Factors for Non-Standard Ducts

next Fig 5.4 for not round steel ducts

Smooth ducts—no joints	.8–.95
Smooth concrete	1.1–1.4
Rough concrete/good brick	1.2–1.8

The *equivalent diameter* of a rectangular air duct with dimensions a and b, and aspect ratio less than 8.0 is

not round

$$D_e = 1.3\,\frac{(ab)^{.625}}{(a+b)^{.25}} \qquad 5.30$$

A round duct with diameter D_e will have the same friction and capacity as a square duct with dimensions a and b. Figure 5.4 can be used with D_e and flow rate to find the friction loss.

If the aspect ratio of the rectangular duct is known, a round duct can be converted to a rectangular duct of equal friction. The *aspect ratio*, which should be kept below 8.0 for ease of manufacturing, is

$$R = \frac{\text{longest side}}{\text{short side}} \qquad 5.31$$

Aspect ratio

The short side, a, is given by equation 5.32.

$$a = \frac{D_e(R+1)^{\frac{1}{4}}}{1.3(R)^{.625}} \qquad 5.32$$

Example 5.6

2000 cfm of air flow in a 13″ diameter duct. What is the velocity and the friction loss per 100 feet of duct?

Although the $Q = Av$ relationship could be used to find the velocity, it is expedient to use figure 5.4. By locating the intersection of the 2000 cfm and the 13″ lines, the velocity is found to be 2200 fpm.

Dropping straight down from the intersection point to the horizontal scale gives the friction loss as approximately .5″ w.g. per 100 feet.

Example 5.7

What size duct is required to carry 2000 cfm at 1600 fpm?

Figure 5.4 shows that a 15″ diameter duct is required.[4] The friction loss is approximately 0.23″ w.g. per 100 feet.

2 MINOR AND DYNAMIC LOSSES

Minor losses are fairly independent of air velocity and roughness. In the *loss coefficient method*, the losses are calculated as a percentage of the velocity pressure.

Minor Losses ∝ P_v

$$p = c\left(\frac{v}{4005}\right)^2 = cp_v \qquad 5.33$$

Typical values of c are given in table 5.3. Subscripts 1 and 2 refer to upstream and downstream, respectively. The coefficient c always should be used with the velocity at the point corresponding to its subscript.

The *equivalent length method* also can be used to calculate the friction of a bend or an elbow. As with equivalent lengths used in liquid flow problems, each obstruction produces a frictional loss equivalent to some length of duct. These lengths are given in multiples of the duct diameter in table 5.3.

[4] Any size duct can be manufactured. However, there are standard sizes available, and these sizes should be chosen to minimize cost. Generally, every whole-inch size up to 20″ diameter is available, although some odd-number sizes may be premium-priced. After 20″, sizes are available in 2″ increments.

Table 5.3
Minor Loss Coefficients

abrupt expansion	$\frac{A_1}{A_2} =$	0	$c_1 =$	1.0
		.1		.81
		.2		.64
		.3		.49
		.4		.36
		.5		.25
		.6		.16
		.7		.09
		.8		.04
		.9		.01
square-edged orifice with area A_0 at exit	$\frac{A_0}{A_1} =$	.2	$c_0 =$	2.44
		.4		2.26
		.6		1.96
		.8		1.54
pipe of diameter E across duct of diameter D	$\frac{E}{D} =$	.1	$c_1 =$	.2
		.25		.55
		.50		2.0
abrupt contraction	$\frac{A_2}{A_1} =$	.2	$c_2 =$	.32
		.4		.25
		.6		.16
		.8		.06
90° smooth round elbow of radius r and diameter D	$\frac{r}{D} =$	.5	$L_e =$	45D
		.75		23D
		1.0		17D
		1.5		12D
		2.0		10D
90° miter elbow			$L_e =$	65D

3 FRICTION LOSSES IN DIVIDED-FLOW FITTINGS

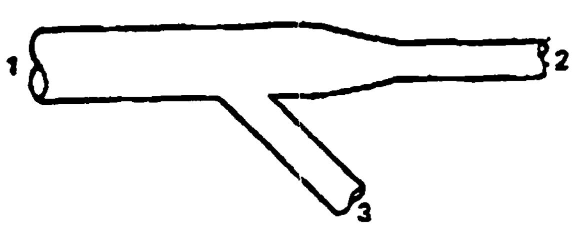


Figure 5.5 Duct with Take-off

If the friction effect of the take-off is ignored, the increase in static pressure due to the decrease in velocity at 2 is

$$\Delta p_{s,1-2} = \frac{v_1^2 - v_2^2}{(4005)^2} \qquad 5.34$$

This increase in pressure will be reduced by the friction and turbulence of the take-off. The amount of reduction is typically between 10% and 25%. This reduction can be represented by multiplying by a coefficient less than 1.0

typically .90 .75

$$\Delta p_{s,1-2} = R\left(\frac{v_1^2 - v_2^2}{(4005)^2}\right) \qquad 5.35$$

P_s increase

Δp is known as the *static regain*, and R is the *static regain coefficient*. R has typical values of .75 to .90 for well-designed ducts without reducing sections.

The total pressure drop from 1 to 2 is

$$\Delta p_{t,1-2} = (1 - R)\left(\frac{v_1^2 - v_2^2}{(4005)^2}\right) \qquad 5.36$$

P_T drop

The friction loss between 1 and 3 can be found from

$$\Delta p_{t,1-3} = c_b\left(\frac{v_1}{4005}\right)^2 \qquad 5.37$$

$$\Delta p_{s,1-3} = \left(\frac{v_3}{4005}\right)^2 - (1 - c_b)\left(\frac{v_1}{4005}\right)^2 \qquad 5.38$$

Values of c_b are given in table 5.4.

Table 5.4
Approximate Values of c_b
(Round mains and branches only)

$\frac{v_3}{v_1}$	90°	60°	45°
.5	1.1	.8	.5
1.0	1.5	.8	.5
1.5	2.2	1.1	.9
2.0	3.0	2.9	2.8
2.5	4.3	3.3	3.2
3.0	5.6	5.2	4.9

4 LOW-VELOCITY DUCT DESIGN

Low velocity duct systems (up to 2500 fpm) are sized and designed by a variety of methods, some of which will be described in this chapter. General recommendations which apply to all duct designs are given here.

- Routes should be as direct as possible.
- Sudden changes in direction and velocity should be avoided.
- Turning vanes should be used whenever possible.
- Rectangular ducts should be as square as possible. Aspect ratios greater than 8:1 should be avoided, and 4:1 or less should be used whenever space permits.
- Smooth metal construction should be used.
- Since calculations are approximate, a fan with some excess capacity should be selected.

MONTGOMERY WATSON

BY [initials] DATE 3/21/99 CLIENT ACS SHEET 3 OF 3

CHKD. BY NWC DESCRIPTION Pressure Loss - SVE Blower System JOB NO.

Pressure loss calculations will be further confirmed by using a published nomograph chart.

section of pipe	pressure loss from spreadsheet	pressure loss from nomograph
① 3" pipe from well field (364 ft)	11.3 in H_2O	2.8 in H_2O per 100 ft = 10.2 in H_2O × 1.2 = 12.2 in H_2O
② 6" header pipe to blower (77 ft)	8.8 in H_2O	6.3 in H_2O per 100 ft = 4.8 in H_2O × 1.2 = 5.8 in H_2O
③ 3" elbow (2; equivalent length = 22 ft)	0.7 in H_2O	2.8 in H_2O per 100 ft = 0.6 in H_2O × 1.2 = 0.7
④ 6" elbow (7; total equivalent length = 62 ft)	7.1 in H_2O	6.3 in H_2O per 100 ft = 3.9 in H_2O × 1.2 = 4.7 in H_2O

Calculated pressure losses are similar to those obtained from nomograph.

· Calculate longest pipe run - 2" pipe. Maintain pressure loss < 12 in H_2O

$$V = \frac{100\,ft^3}{min} \times \frac{1}{\pi \left(\frac{2}{2.12}\right)^2 ft^2}$$

$$\boxed{V = 4584\ \frac{ft}{min}}$$

$$12\text{ in } H_2O = \left[(3.9 \times 10^{-9})\left(4584\frac{ft}{min}\right)^{2.43} \frac{L}{\left(\frac{100\,ft^3}{min}\right)^{0.61}}\right]^{1.2}$$

$$\boxed{L = 54\,ft}$$

∴ All pipe runs > 55 ft should be 3" pipe

O.K.

SN 1S (10/78)

from Mechanical Engineering Reference Manual, 8th Clifton

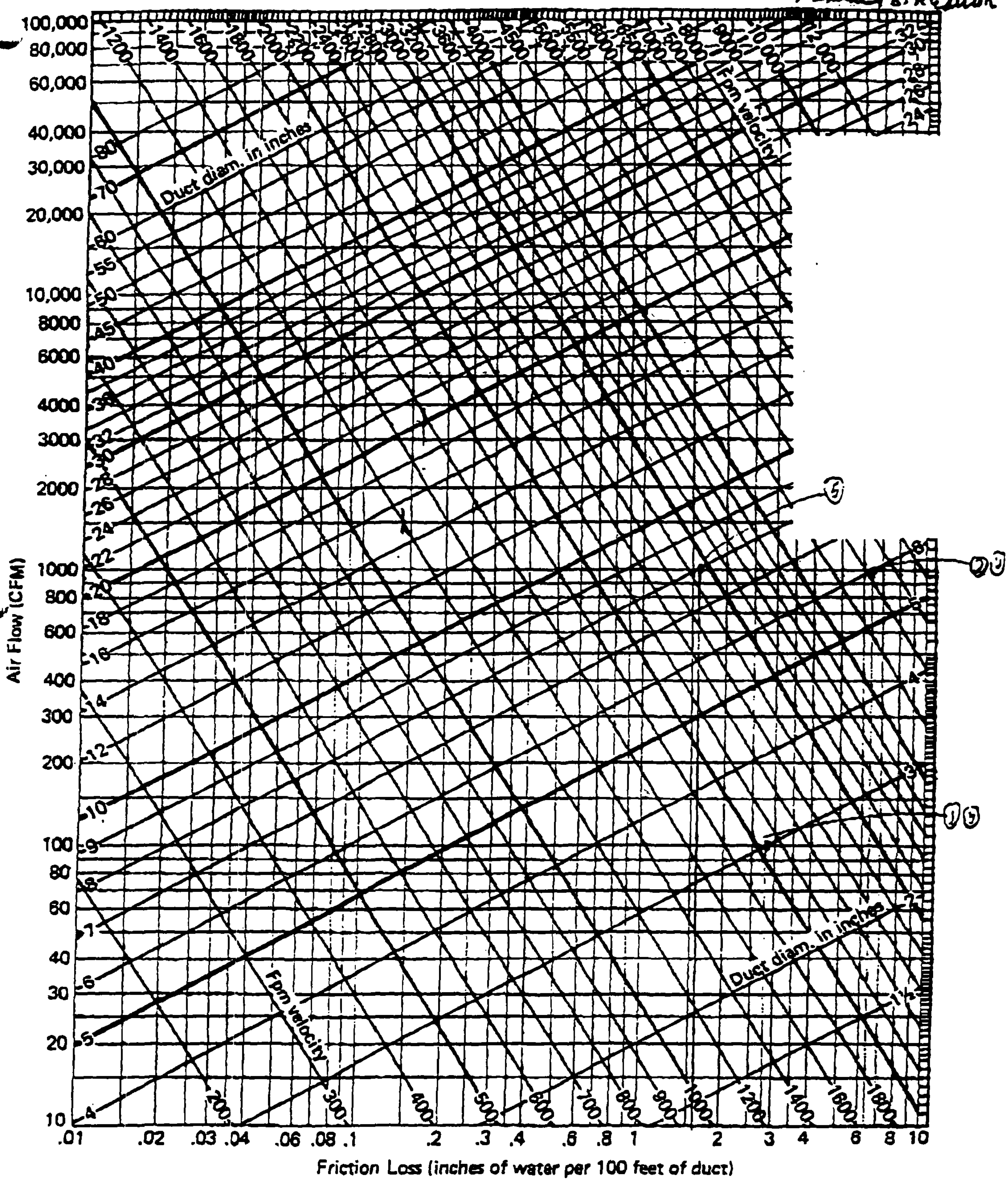


Figure 5.4 Friction Loss in Inches of Water per 100 Feet Standard Duct

MONTGOMERY WATSON

Telephone Discussion Notes

Subject:

Discussion:

* · 2-3" H_2O head loss through knockout tank - most from impingement points

* · 500 gal knockout tank means 300 gal water capacity
  mount demister on top of tank - allow 2' of height
  allow additional 1' for access to demister
  allow ~1 ft headspace above water storage
  baffels included to prevent liquid surging from surging blower
  Can build to whatever size we want

have never built a 500 gal knockout tank

Montgomery Watson Party	Other Party
Project Name: ACS	Company Name: Catalytic Combustion
Project No. ______ Billable? Yes, No	Address:
Employee Name: Ken Lewis	Phone No.
Date: 3/22/99 Time:	Person Name: John Streng

Call placed by: MW ____, Other Party ____

GO-60 (10/84)

MONTGOMERY WATSON

BY Kat DATE 4/5/99 CLIENT ACS SHEET 1 OF 2
CHKD. BY AM 5/7/99 DESCRIPTION Pressure Loss - SVE Blower System JOB NO.

Off-site / KP area - discharge end

- blower sized for 1000 scfm. Pressure at blower discharge will be higher than at end of pipe ∴ flow will be lower. However, to be conservative, assume flow in entire pipe run = 1000 cfm.

- calculate pressure loss using following equation (see calcs for off-site / KP area - vacuum end for all references)

$$P_{loss} = (3.9 \times 10^{-9}) V^{2.43} \frac{L}{Q^{0.61}}$$

P_{loss} = pressure loss, inches water
L = length, ft
V = velocity, ft/min
Q = flow rate, cfm

pipe length : 1250 ft from blower bldg to treatment bldg
28 ft inside blower bldg
32 ft inside treatment bldg
TOTAL = 1310 ft

assume 8" pipe

$$V = \frac{1000 \, ft^3}{min} \times \frac{1}{\pi \left(\frac{8}{2 \cdot 12}\right)^2 ft^2}$$

$\boxed{V = 2865 \frac{ft}{min}}$ ✓ O.K.

$$P_{loss} = (3.9 \times 10^{-9}) \left(2865 \frac{ft}{min}\right)^{2.43} \frac{(1310 \, ft)}{\left(1000 \frac{ft^3}{min}\right)^{0.61}}$$

$\boxed{P_{loss} = 19.0 \text{ inches water}}$

with safety factor of 20%, $P_{loss} = (19.0)(1.2)$

$\boxed{P_{loss} = 22.8 \text{ inches water}}$

MONTGOMERY WATSON

BY KHR DATE 4/5/99 CLIENT ADS SHEET 2 OF 2
CHKD. BY [illegible] DESCRIPTION Pressure Loss: SVE Blower System JOB NO.

· Confirmation, turbulent flow:

in 8" pipe, v = 48 ft/sec (see spreadsheet)

$$N_{Re} = \frac{\left(\frac{8}{12}\right) ft \ (48\ ft/sec)}{16.0 \times 10^{-5}\ \frac{ft^2}{sec}}$$

$$\boxed{N_{Re} = 200{,}000} \quad \therefore \text{turbulent}$$

A summary of the pressure loss for the overall SVE system - discharge side - is provided in the attached spreadsheet.

· Confirm calculation using nomograph:

section of pipe	pressure loss from spreadsheet	pressure loss from nomograph
(3) 1310 ft 8" pipe	22.8 in H_2O	1.5 in H_2O per 100 ft · 19.6 in H_2O × 1.2 = 23.6 in H_2O

Calculated pressure loss similar to that obtained from nomograph.

SVE Pressure Loss, Discharge Side of Blower
Off-Site/[illegible] reas

Pipe or Fitting	Flow Rate (scfm)	Number of fitting	Eq. Length per fitting (1) (ft)	Length of Pipe or Eq. Length of Fittings (ft)	Diameter of Pipe or Fitting (inches)	Velocity (fpm)	Velocity (fps)	Pressure Loss (2) (inches water)	Cummulative Pressure Loss (inches water)
8" blower discharge to oxidizer	1000	-	-	***1310***	8	2865	48	22.82	[redacted]
8" standard 90 elbow	1000	9	12.0	108	8	2865	48	1.88	[redacted]
8" tee	1000	1	24.0	24	8	2865	48	0.42	[redacted]
8" butterfly valve	1000	1	***3.2***	3	8	2865	48	0.06	[redacted]
silencer	1000							***2.22***	[redacted]

4

Velocity Equation v (fpm) = Q - flow rate (scfm) / 3.15159 x (d - diameter (in) / 24) ^ 2

Pressure Loss Ploss (inches water) = 3.9EE-9 * v - velocity (fpm) ^ 2.43 * L - length (ft) / Q - flowrate (scfm) ^ 0.61

(1) from Mechanical Engineering Reference Manual, 8th Edition; Michael R. Lindeburg, P.E., p 3-21
(2) Includes 20% safety factor

Cells with italicized bold print have attached comment.

KAL/kal/BL
J:\1252\042\280101\1252042281003.xls

Cell: E7
Comment: kalewis:
1250 ft from blower bldg to treatment bldg;
28 ft inside blower bldg (20 vertical, 8 horizontal);
32 ft inside treatment bldg (15 vertical, 17 horizontal)

Cell: C8
Comment: kalewis:
4 in blower building and 5 in groundwater treatment building

Cell: D10
Comment: kalewis:
Assume equal to gate valve; From Perry's Handbook, K value for butterfly valve, 5 deg angle = 0.24; K value for open gate valve = 0.17

Cell: I11
Comment: kalewis:
From Stoddard Silencers

KAL/kal/BL

DESIGN MEMORANDUM

To: **File**

From: **R. Adams**

Reference: **Groundwater Extraction System Flow Rates**
American Chemical Services NPL Site
Griffith, Indiana

Date: **April 29, 1999**

Project No.: 1252042.28350103

The flow rate requirements for the groundwater extraction system during implementation of the Final Remedy were calculated based on groundwater level requirements and implementation schedule requirements for the ISVE systems and hydraulic and contaminant influent capacities of the groundwater treatment plant (GWTP). Infiltration rates and preliminary groundwater extraction rates were included in the 30% Remedial Design (RD) report. These flow rate calculations were based on an outdated remediation implementation schedule; therefore, they needed to be recalculated with the current schedule. Based on the 30% RD and the updated implementation schedule, the groundwater extraction system would need to be capable of accomplishing the following tasks.

- Lowering of the water table in the Off-Site Area by approximately 8 feet to allow more effective operation of the ISVE systems that will be installed in the Off-Site Containment Area (OFCA) and the Kapica-Pazmey Area (K-P Area);

- ISVE condensate collected in the knockout tanks of the ISVE systems that will be installed in the OFCA and the K-P Area;

- Lowering of the water table in the On-Site Area by approximately 5 feet to allow more effective operation of the ISVE system that will be installed in the Still Bottoms Pond Area (SBP);

- ISVE condensate collected in the knockout tank of the ISVE system that will be installed in the SBP; and

- Continued operation of the PGCS.

Based in Site-specific information and the 30% RD requirements, the following information and assumptions were utilized to calculate the required flow rates needed to accomplish these tasks:

- A bentonite slurry wall will be installed to create a barrier between the On-Site Area and Off-Site Area to allow for independent dewatering and groundwater level maintenance in each area.

- The soil at the Site has a porosity of 0.3, and the pumping rates of any new trenches would equal the historic pumping rates from an existing trench of the same size.

- Flowrates from the existing extraction trenches in the Off-Site and On-Site Area were estimated based on historical BWES flowrates and estimated groundwater and stormwater infiltration rates obtained utilizing the HELP model.

- The estimation of flowrates from the Off-Site Area assumes that a clay cover will be installed to cover the entire area. The HELP model and infiltration calculations for the cover resulted in a projected groundwater and stormwater infiltration rate of less than one gallon per minute (gpm). The HELP model results and calculations are contained in the 30% Remedial Design Report.

- The estimation of flowrates from the On-Site Area assumes that one-third of the area will be capped to significantly reduce groundwater infiltration in the SBP Area. The HELP model and infiltration calculations resulted in a projected groundwater and stormwater infiltration rate ranging from approximately 6 to 12 gpm. The increased infiltration rates are the result the inability to completely cover the On-Site due to continued operation of the American Chemical Services, Inc. facility. The HELP model results and calculations are contained in the 30% Remedial Design Report.

- ISVE condensate flows from the OFCA, K-P Area, and SBP ISVE systems were estimated assuming that the collected vapor contained 100 percent water vapor saturation and 50 percent of the vapor was condensed in knock-out tanks.

- The flow from the PGCS was estimated based on historical groundwater pumping rates from the PGCS extraction trench since completion of the barrier wall.

- Flowrates from the additional extraction trenches were estimated to be the difference between the current maximum pumping rates and the groundwater pumping rates needed to lower the groundwater table in the Off-Site Area eight feet in 12 months.

- Flowrates from the additional extraction wells that will be installed in the On-Site Area were estimated to be the difference between the current maximum pumping rates and the groundwater pumping rates needed to lower the groundwater table in the On-Site Area five feet in eight months.

- The hydraulic and contaminant loading to the GWTP from the extraction system will be need to be within ranges that can be effectively treated by the GWTP.

Using these assumptions, required groundwater extraction rates from each area, the On-Site Area and Off-Site Area, were calculated (Attached). Based on these calculations and requirements it was determined that the flow rate capacity and operational control of the existing groundwater extraction system would need to be increased

RAA
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1252042.28350103

MONTGOMERY WATSON

By RAA	Date 8/17/99	Client ACS	Sheet 1 of 1
Chkd. By SJS	Description DEWATERING VOLUMES		Job No. 1252042

SUMMARY OF INFILTRATION RATES OBTAINED FROM 30% RD.

- OFF-SITE AREA (W/ EXISTING 12" CLAY CAP)

  INFILTRATION = 0.0042 GPM

  THIS RATE WAS ROUNDED UP TO 1 GPM FOR FINAL CALCULATIONS

- ON-SITE AREA

  THE ON-SITE AREA IS DIVIDED INTO 2 AREAS - STILL BOTTOMS BOND AREA & REMAINING

  INFILTRATION @ STILL BOTTOMS POND AREA WITH CAP = 0.002 GPM

  REMAINING AREAS

  - W/ 70% RUN.OFF = 6.01 GPM

  TOTAL (BOTH ON-SITE AREAS)

  INFILTRATION = 6.01 GPM + 0.002 GPM
  = 6.012 GPM
  ≈ 6 GPM

  FOR A CONSERVATIVE ESTIMATE, TWO TIMES ON-SITE INFILTRATION RATE WAS USED AS MAX

  $INFILTRATION_{min}$ = 6 GPM

  $INFILTRATION_{max}$ = 2(6 GPM) = 12 GPM

MONTGOMERY WATSON

By RAA Date 8/17/99 Client ACS Sheet 2 of 5

Chkd. By SJS Description DEWATERING VOLUMES Job No. 1252042

ON-SITE AREA

- CALCULATE VOLUME OF WATER TO BE DEWATERED IN ON-SITE AREA. DRAW DOWN REQUIRED = 5'
- CALCULATE FLOWRATE NEEDED TO DRAW DOWN WATER 5' WITHIN 8 MONTH PERIOD
- DETERMINE ADDITIONAL FLOW RATES NEEDED TO ACCOMPLISH DEWATERING OBJECTIVES IN ON-SITE AREA
- KNOWNS
  - DRAWDOWN = 5'
  - AREA = 15 ACRES = 653,403 SF
  - REMOVAL TIME = 8 MONTHS
  - THERE ARE 3 EXISTING 100' EXTRACTION TRENCH
- ASSUMPTIONS
  - EACH 100' EXTRACTION TRENCH HAS A SUSTAINABLE PUMPING CAPACITY OF 2 GPM. (BASED ON HISTORICAL PUMPING DATA)
  - INFILTRATION WILL BE 6 TO 12 GPM
  - SOIL POROSITY = 30%
- CALCULATIONS

1) CALCULATE VOLUME OF WATER TO BE REMOVED

V = AREA × DEWATED DEPTH × SOIL POROSITY

= 653403 SF × 5 FT × 30%

= 980105 CF × 7.48 $\frac{GAL}{CF}$

= 7,331,691 GALLONS

MONTGOMERY WATSON

By RAA Date 8/17/99 Client ACS Sheet 3 of 5

Chkd. By SJS Description DEWATERING VOLUMES Job No. 1252042

2) CALCULATE PUMPING RATE (IN GPM) REQUIRED TO DEWATER 7,331,691 GAL IN 8 MONTHS.

8 MONTHS = (8/12) YEAR

$$Q = 7{,}331{,}691 \text{ GAL} \times \frac{1 \text{ YR}}{(8/12)(365) \text{ DAYS}} \times \frac{1 \text{ DAY}}{24 \text{ HR}} \times \frac{1 \text{ HR}}{60 \text{ MIN}}$$

$Q = 21$ GPM REQUIRED TO DEWATER ON-SITE AREA IN 8 MONTHS W/O INFILTRATION

INFILTRATION = 6-12 GPM

$Q_{MIN} = 21$ GPM + 6 GPM = 27 GPM

$Q_{MAX} = 21$ GPM + 12 GPM = 33 GPM

PUMPING RATE REQUIRED TO DEWATER ONSITE AREA
Q = 27 - 33 GPM

3) ADDITIONAL FLOWRATE REQUIRED OVER EXISTING EXTRACTION SYSTEM

- EACH EXISTING TRENCH (3 TOTAL) HAS Q = 2 GPM

33 GPM - 2 GPM (3) = 27 GPM

27 GPM - 2 GPM (3) = 21 GPM

ADDITIONAL EXTRACTION TRENCHES/WELLS CAPABLE OF SUSTAINING A PUMPING RATE OF 21 TO 27 GPM WILL BE REQUIRED.

MONTGOMERY WATSON

By RAA Date 8/17/99 Client ACS Sheet 4 of 5

Chkd. By SJS Description DEWATERING VOLUMES Job No. 1252042

OFF-SITE AREA

- CALCULATE VOLUME OF GROUNDWATER TO BE DEWATERED IN OFF-SITE AREA. REQUIRED DRAWDOWN IS 8'
- CALCULATE FLOWRATE REQUIRED TO DRAWDOWN WATER IN OFF-SITE AREA 8' IN 12 MONTH PERIOD
- DETERMINE ADDITIONAL FLOWRATE REQUIRED TO ACCOMPLISH DEWATERING OBJECTIVES.
- KNOWNS
  - DRAWDOWN = 8'
  - AREA = 552820 SF
  - REMOVAL TIME = 1 YEAR
  - THERE ARE 5 EXISTING 100' EXTRACTION TRENCHES
- ASSUMPTIONS
  - SAME AS ON-SITE AREA CALCULATIONS EXCEPT INFILTRATION = 1 GPM (DUE TO EXISTING CLAY CAP)
- CALCULATIONS

1) VOLUME OF GROUNDWATER TO BE REMOVED

$V = (552820\ SF)(8')(30\%)$

$= 1,359,077\ CF$

$\approx 10,166,600$ GALLONS

2) CALCULATE REMOVAL RATE REQUIRED TO PUMP 10,166,600 GAL IN 12 MONTHS.

$$Q = \frac{10,166,600\ GAL}{YR} \times \frac{YR}{365\ DAY} \times \frac{1\ DAY}{24\ HR} \times \frac{1\ HR}{60\ MIN}$$

$Q = 19.3$ GPM W/O INFILTRATION

INFILTRATION = 1 GPM (FROM HELP MODEL)

Q= 20.3 GPM (W/ INFILTRATION)

3) ADDITIONAL FLOW RATE REQUIRED TO MEET DEWATERING OBJECTIVES

EXISTING DEWATERING CAPACITY = 5(2 GPM) = 10 GPM

ADDITIONAL PUMPING RATE REQUIRED

20.3 GPM − 10 GPM = 10.3 GPM

10.3 GPM ADDITIONAL WILL ~~BE~~ REQUIRED

Table 1
Estimated Flows and Scheduling to the Treatment System
American Chemical Services NPL Site,
Griffith, Indiana

Stage	Operating Period	PGCS (gpm)	SBP ISVE (gpm)	OFCA ISVE (gpm)	Existing Off-Site Trenches (gpm)	Additional Off-Site Trenches (gpm)	Existing On-Site Trenches (gpm)	Additional On-Site Wells (gpm)	SBP Design Safety Flow (gpm)	OFCA Design Safety Flow (gpm)	Total (gpm)
		Flow									
		Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
1 Off-Site Area Dewatering	Start-up to 1 year	5 - 10	0 - 0	3 - 8.5	10 - 10	10 - 10	0 - 6	6 - 6	0 - 0	2.5 - 8.5	**36.5 - 59**
2 On-Site Area Dewatering	1 year to 1 year, 8 mo.	5 - 10	0 - 0	3 - 8.5	1 - 0	0 - 1	6 - 6	21 - 27	0 - 0	2.5 - 8.5	**38.5 - 61**
3 Maintenance Dewatering	1 year, 8 mo. +	5 - 10	0.2 - 5	3 - 8.5	1 - 0	0 - 1	0 - 6	6 - 6	0.1 - 5	2.5 - 8.5	**17.8 - 50**

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ATTACHMENT

Historical Groundwater Elevations in the Vicinity of the Barrier Wall
American Chemical Service NPL Site
Griffith, Indiana

Water levels have been collected at piezometers and monitoring wells inside and outside the barrier wall, on a quarterly basis, since the completion of the barrier in 1997. Eight sets of piezometers were installed with one piezometer just inside the wall and the other just outside, at eight locations around the wall. These piezometers are number P-93 through P-108. The even numbered piezometers are inside the barrier wall and the odd numbered ones are located on the outside of the barrier wall.

Seven sets of groundwater elevation data have been collected for the piezometers and these are listed on Table 1. In addition, the data has been included for 13 other piezometers that are part of the groundwater monitoring network. A set of graphs has been developed from the data. There is one graph for each piezometer pair. In each pair, the even numbered piezometer reports the water level inside the barrier wall and the odd numbered piezometer reports the water level outside the barrier wall.

In general, we have maintained the water levels inside the barrier wall at approximately 634 feet above mean sea level (amsl). This is the level at which we can assure that there will be no over flow of the barrier wall. When the biological upgrade to the system is completed, the pumping rates will be maximized to begin the process of lowering the water level for the soil vapor extraction system (SVE).

A barrier wall will also be installed in the vicinity of the central railroad tracks to divide the site into a north and south half. During the SVE process, the water level will be drawn down to 626 feet amsl in the Off-Site Containment Area (OFCA) and to a level of 629 feet amsl in the Still Bottoms Pond Area (SBPA). Following completion of the SVE, the water level inside the barrier wall will be allowed to rebound to a target elevation of 631. We expect a plus/minus one-foot level variability with time and space inside the wall. Therefore, we expect to maintain the water levels within the range of 630 and 632 feet amsl inside the barrier wall for the long term.

Average and lowest groundwater levels have been developed from the data in Table 1. Figure 1 includes a plot of the observed average groundwater levels outside the barrier wall and a groundwater elevation of 631 inside the barrier wall. The barrier wall is marked to indicate where the gradients will be inward and where they may be outward. Figure 2 is similar except it contains a plot of the lowest measured groundwater levels outside the barrier wall.

Table 1. Groundwater Elevations in the Vicinity of the Barrier Wall
American Chemical Service NPL Site
Griffith, Indiana

Well Designation	Location	East	North	TOC	Groundwater Elevations Mar-97	Sep-97	Dec-97	Jun-98	Sep-98	Nov-98	Mar-99	Jun-99	Standard Deviation	Average
P-3	I	5453	6470	639.87	635.68	nm	635.57	635.96	634.19	634.56	634.62	635.40	0.67	635.14
P-5	I	5285	6510	636.70	634.90	635.37	635.40	634.18	631.87	634.52	633.29	634.28	1.17	634.23
P-7	E	5950	6630	643.63	636.13	633.20	632.82	635.51	632.59	632.03	634.64	635.32	1.55	634.03
P-9	E	6134	6994	638.88	635.78	632.97	632.74	635.00	632.13	631.80	634.58	634.92	1.50	633.74
P-11	I	5199	5900	649.14	635.49	636.42	635.79	636.53	634.75	634.47	634.21	634.89	0.88	635.32
P-13	LF	4878	5735	651.20	634.90	632.40	631.47	634.51	632.32	631.30	632.98	633.86	1.35	632.97
P-29	E	5738	6619	642.37		635.74	635.52		634.43	634.51	634.07	635.62	0.73	634.98
P-32	I	5746	7026	642.32	635.37	635.69	635.59	635.23	634.61	634.62	635.41	635.52	0.42	635.26
P-39	I	5940	6902	642.00	635.80	635.68	635.50	635.58	634.44	634.55	635.20	635.65	0.53	635.30
P-40	I	5931	7241	638.77	634.91		632.52	634.36	632.09	631.73	634.27	634.67	1.34	633.51
P-41	N	5663	7377	637.23	634.34		631.92	633.18	631.57	631.61	633.42	633.70	1.11	632.82
P-49	I	5145	6949	638.98	633.88		635.71	634.87	634.12	634.70	634.78	635.15	0.61	634.74
P-55	ditch	5628	7979	636.08	631.70	629.70	630.69	630.27	627.76	629.76	631.21	630.97	1.22	630.26
P-93	W	5136	7067	638.79			631.41	631.40	630.29	630.37	632.49	632.14	0.90	631.35
P-94		5146	7061	638.98										
P-95	W	5146	6532	638.58		628.29	628.84	629.87	629.23	629.16	632.53	631.19	1.49	629.87
P-96	I	5156	6537	638.39		635.43	635.40	629.94	626.77	634.51	630.18	632.11	3.28	632.05
P-97	W	5098	6283	638.39		629.34	629.63	630.79	629.99	629.43	632.49	631.71	1.23	630.48
P-98	I	5130	6279	639.35		636.56	636.05	633.40	627.87	634.31	631.99	632.37	2.92	633.22
P-99	W	5020	5945	644.35		631.98	631.16	634.18	631.98	631.09	633.45	633.65	1.25	632.50
P-100	I	5031	5948	643.93		636.89	636.17	634.18	634.65	634.55	634.21	634.84	1.05	635.07
P-101	E	5550	5979	650.08			631.23	635.19	632.53	631.68	633.75	634.76	1.63	633.19
P-102	I	5517	5996	647.18			635.78	636.58	634.44	634.62	634.44	635.38	0.87	635.21
P-103	E	5672	6248	644.97			632.62	635.01	632.27		633.77	634.67	1.21	633.67
P-104	I	6267	5639	646.68			635.70	636.43	634.46	634.64	634.66	635.57	0.78	635.24
P-105	E	6678	5885	638.86			632.96	635.66	632.73	632.16			1.56	633.38
P-106	I	6685	5871	638.10			635.07	635.43	633.95	634.14			0.72	634.65
P-107	N	5766	7339	637.42		631.62	631.61	633.35	631.19	631.02	633.42	633.81	1.19	632.29
P-108	I	5757	7324	638.13		635.38	635.25	634.78	634.33	634.51	635.14	635.13	0.40	634.93

Notes:

Blank cells indicate that data is not available for that date and location

I Indicates that piezometer is inside the barrier wall

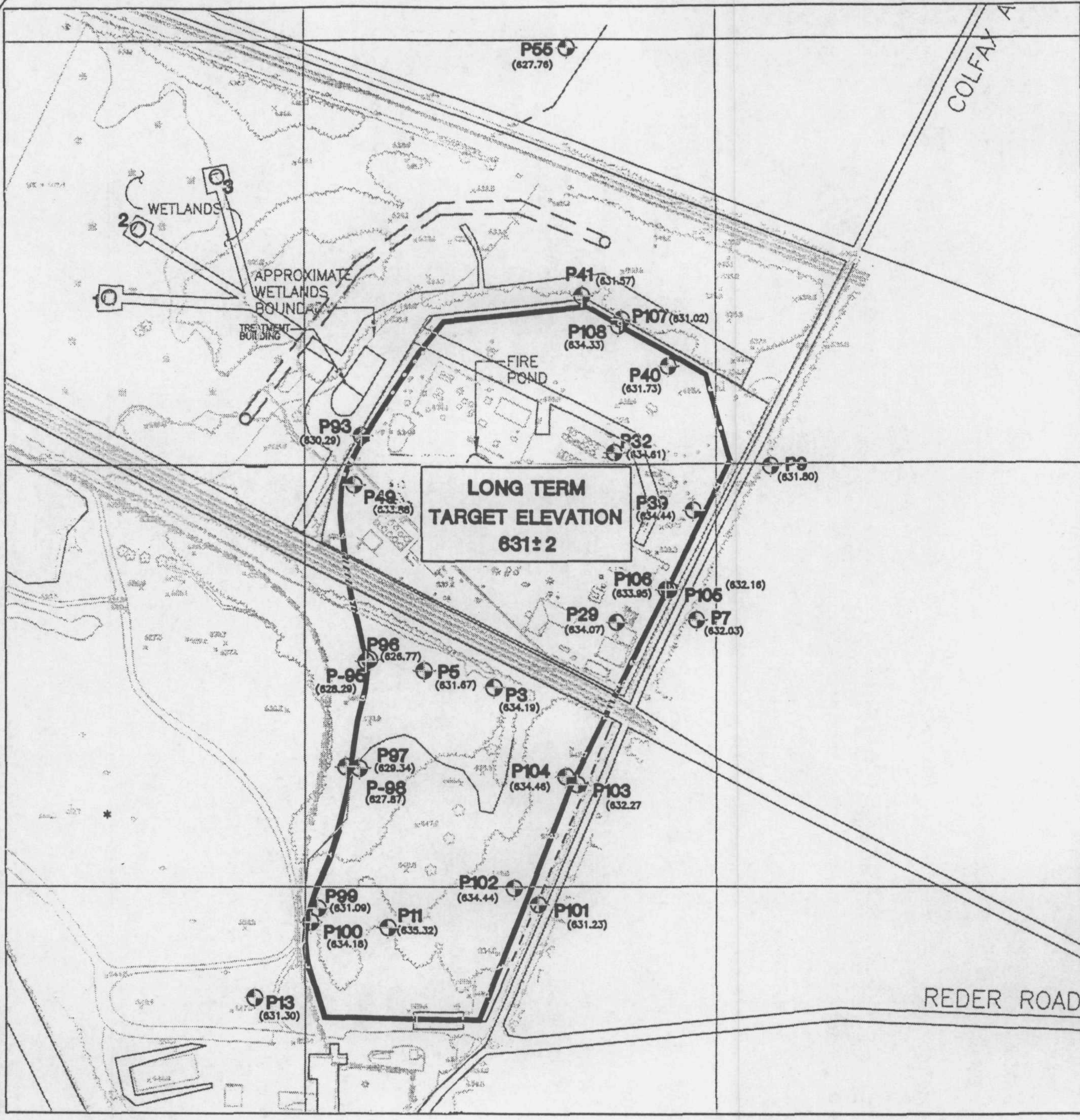
N Indicates that piezometer is north of the barrier wall

E Indicates that piezometer is east of the barrier wall

W Indicates that piezometer is west of the barrier wall

LF Indicates that piezometer is in the town landfill, west of the barrier wall

ditch Indicates that piezometer is near the drainage ditch, 1,000 feet north of the barrier wall



LEGEND

P106 — PIEZOMETER LOCATION AND DESIGNATION

(631.56) — ELEVATION

BARRIER WALL

GRIFFITH LANDFILL BOUNDARY

PERIMETER GROUND WATER CONTAINMENT SYSTEM

north

0 175 350

SCALE IN FEET

NOTE

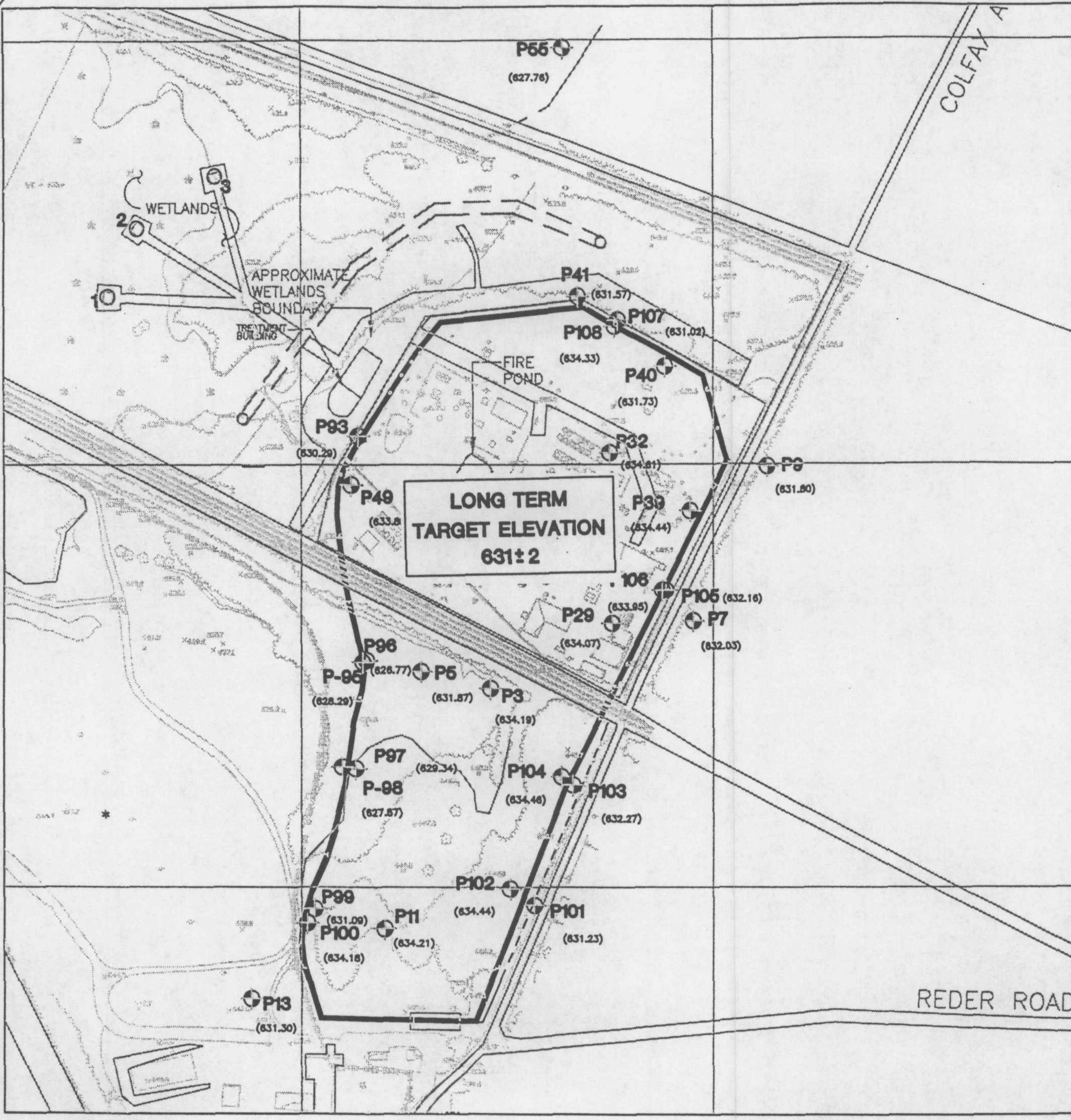
1. GROUNDWATER ELEVATIONS WERE MEASURED AT THE SITE ON MARCH 22, 1999

MONTGOMERY WATSON
Chicago, Illinois

AMERICAN CHEMICAL SERVICE, INC.
NPL SITE
GRIFFITH, INDIANA

AVERAGE
GROUNDWATER LEVEL

FIGURE
1



LEGEND

P106 — PIEZOMETER LOCATION AND DESIGNATION

(631.56) — ELEVATION

BARRIER WALL

GRIFFITH LANDFILL BOUNDARY

PERIMETER GROUND WATER CONTAINMENT SYSTEM

NOTE

1. GROUNDWATER ELEVATIONS WERE MEASURED AT THE SITE ON MARCH 22, 1999

north

0 175 350

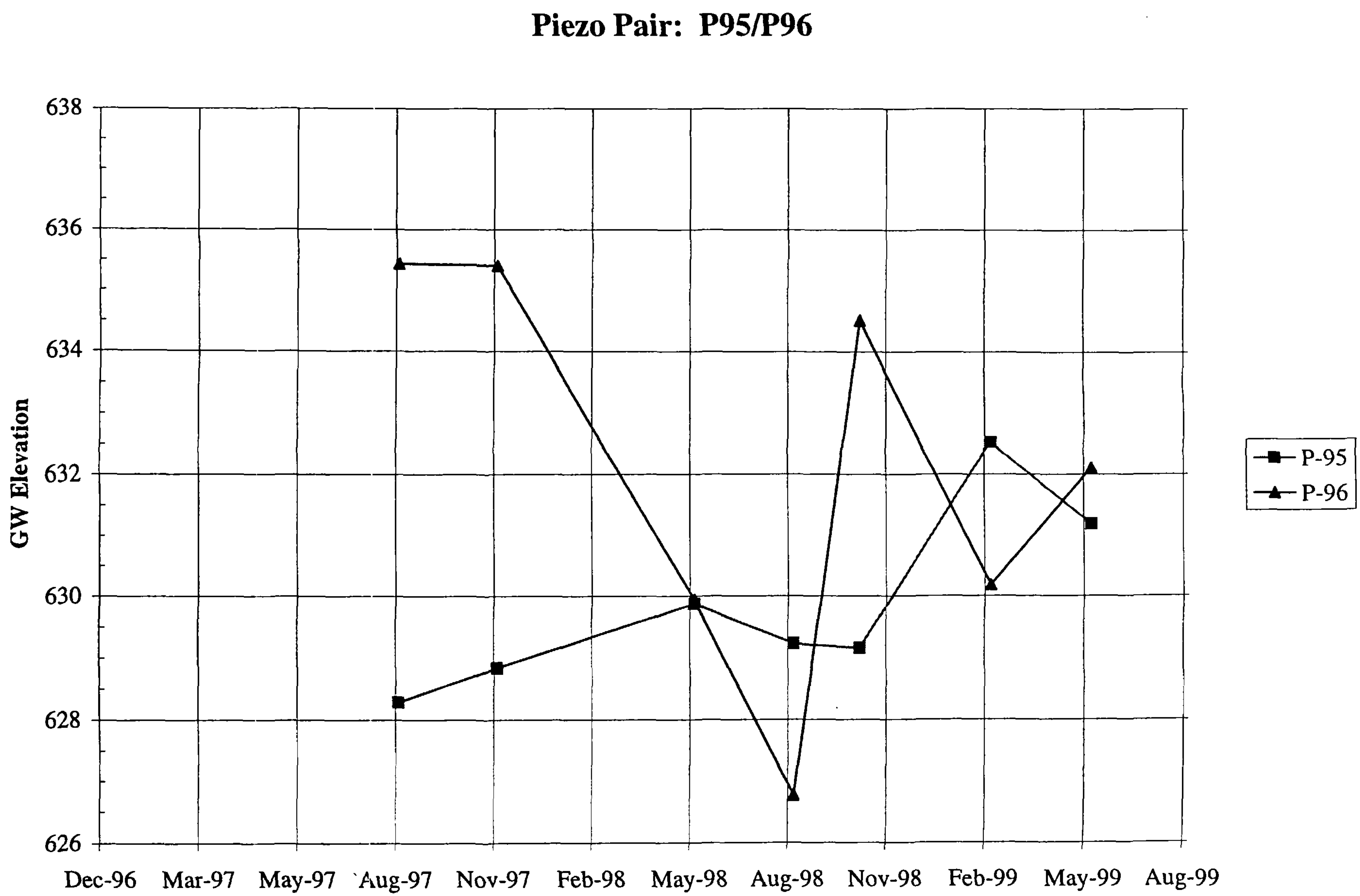
SCALE IN FEET

MONTGOMERY WATSON
Chicago, Illinois

AMERICAN CHEMICAL SERVICE, INC.
NPL SITE
GRIFFITH, INDIANA

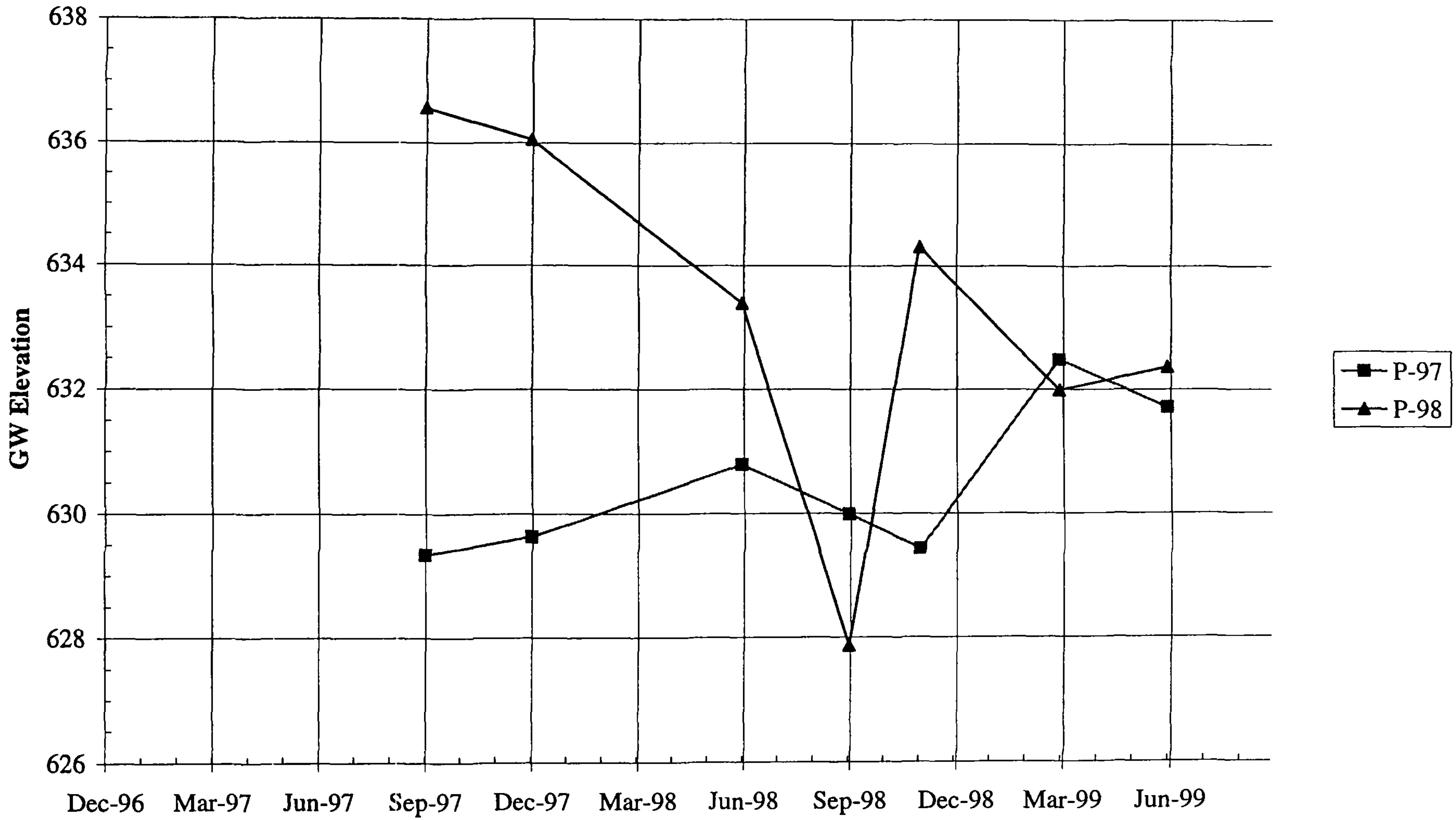
LOWEST RECORDED GROUNDWATER LEVEL

FIGURE 2

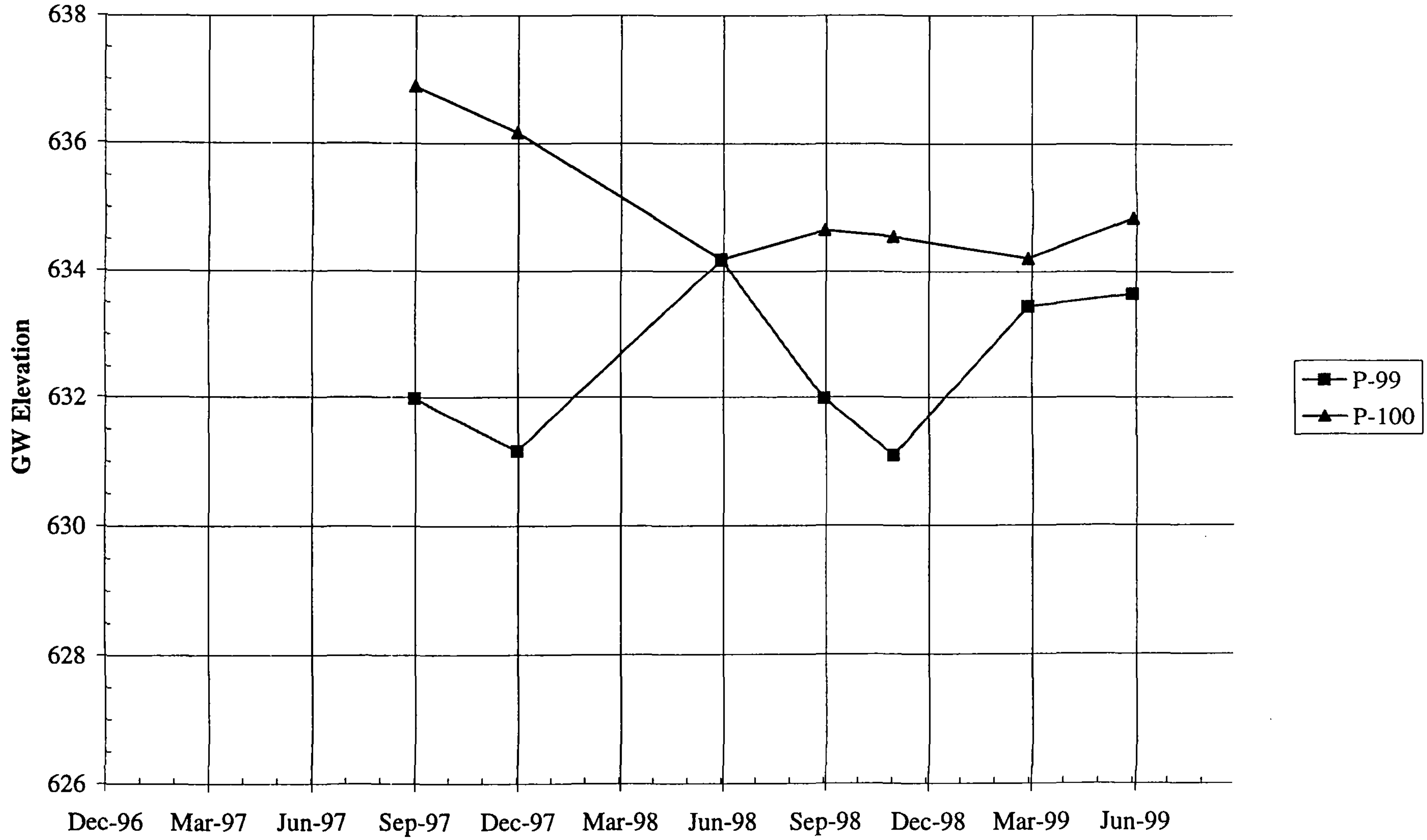


Piezo Pair: P95/P96
638
636
634
632
630
628
626
GW Elevation
Dec-96
Mar-97
May-97
Aug-97
Nov-97
Feb-98
May-98
Aug-98
Nov-98
Feb-99
May-99
Aug-99
P-95
P-96

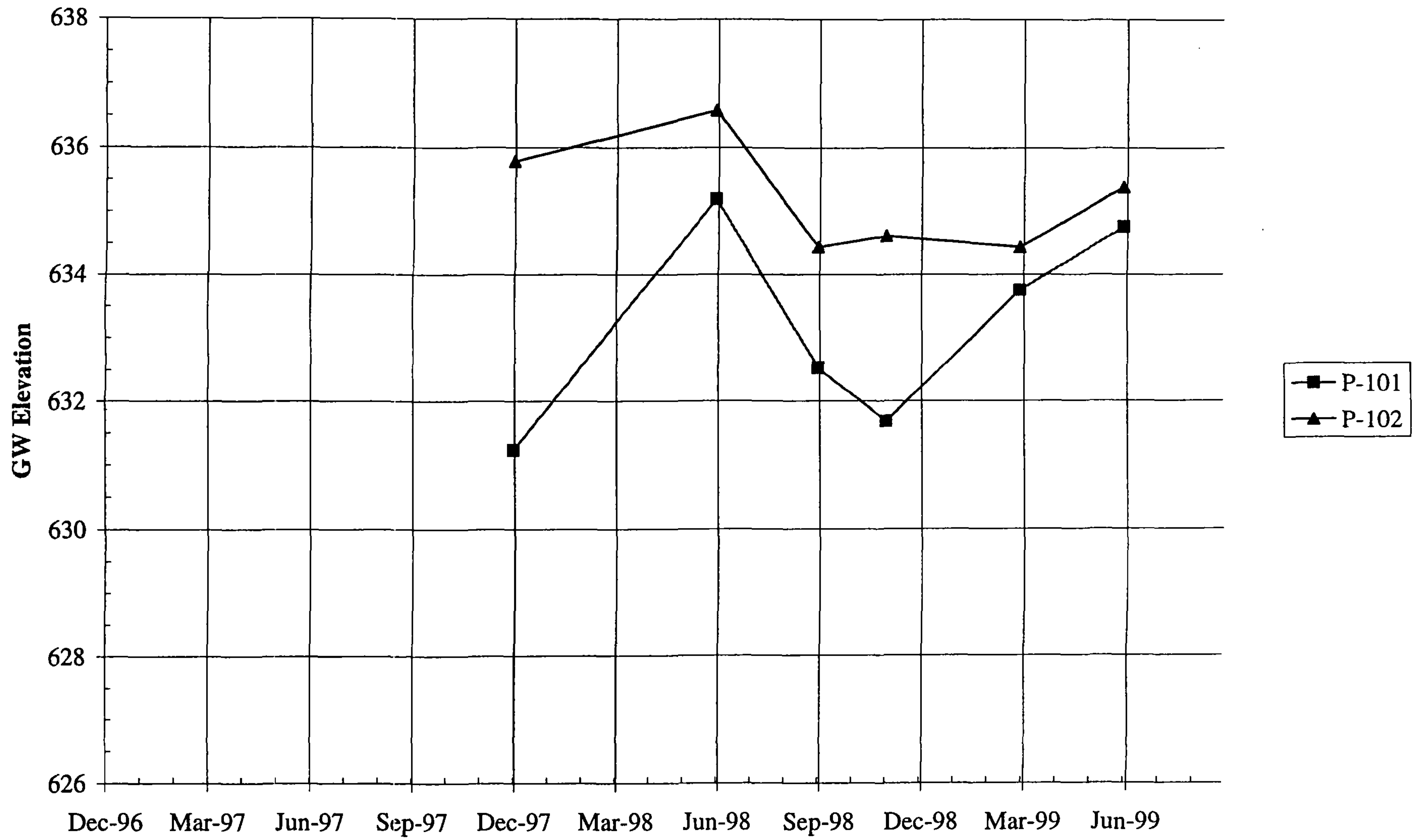
Piezo Pair: P97/P98

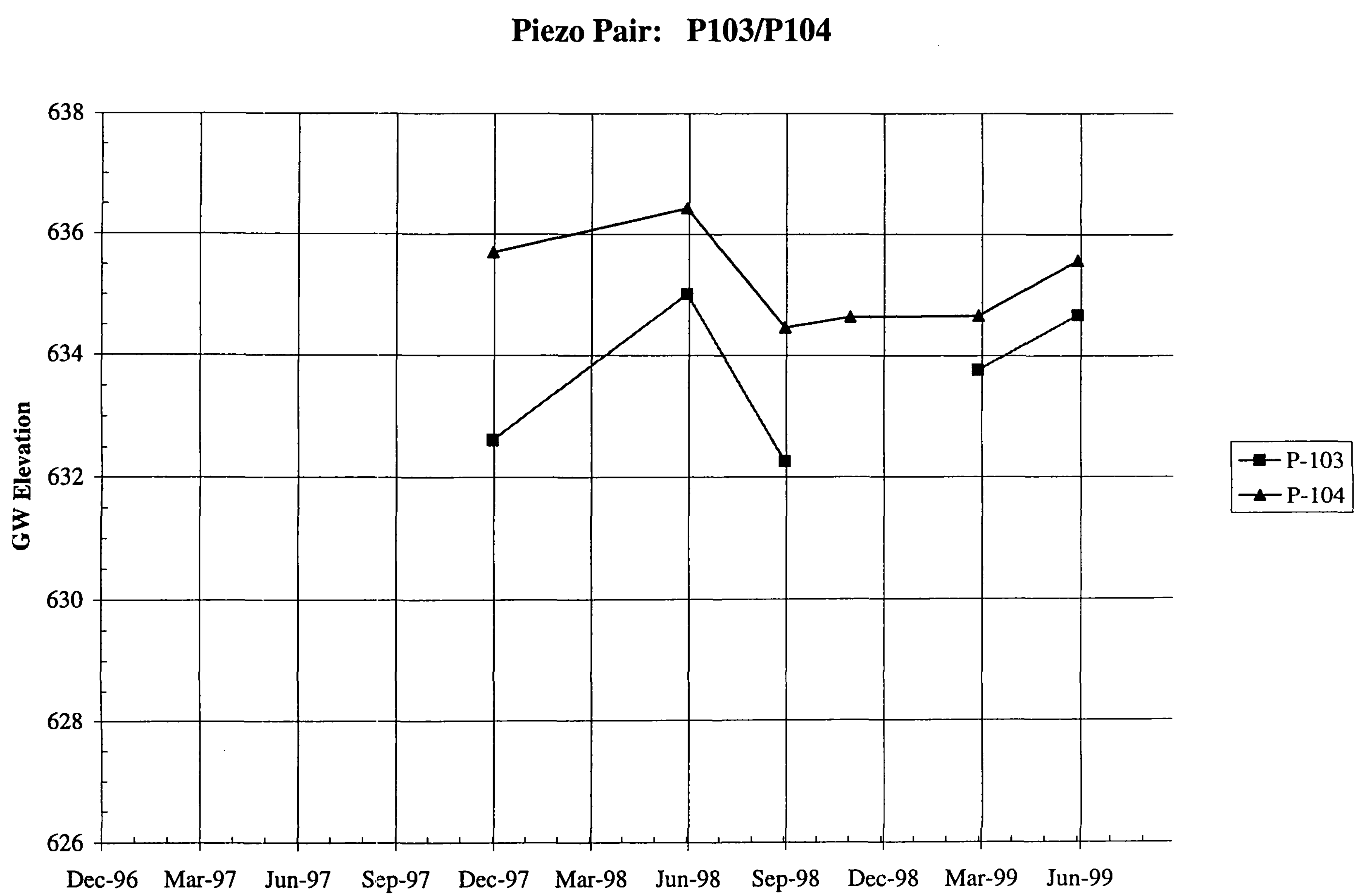


Piezo Pair: P99/P100



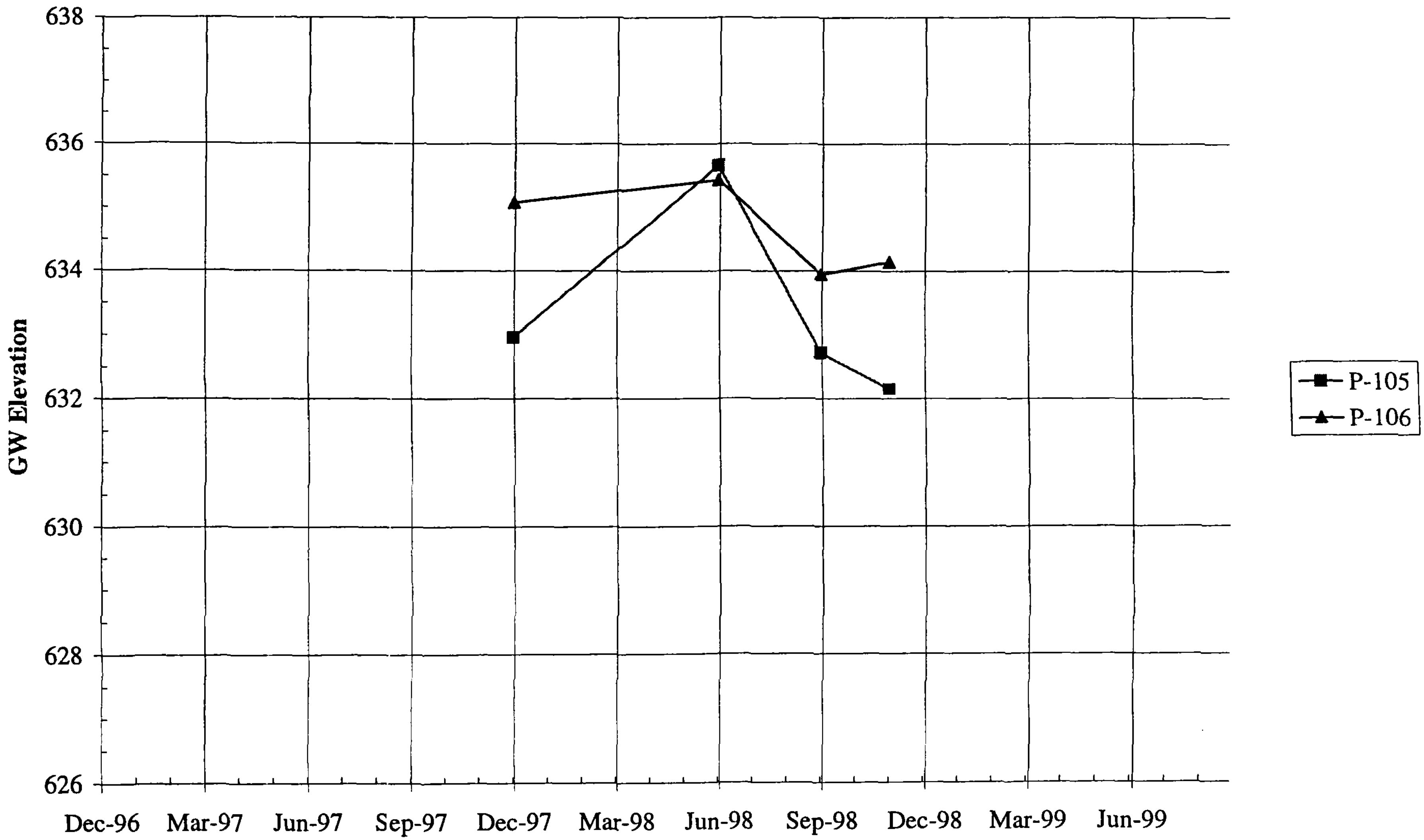
Piezo Pair: P101/P102



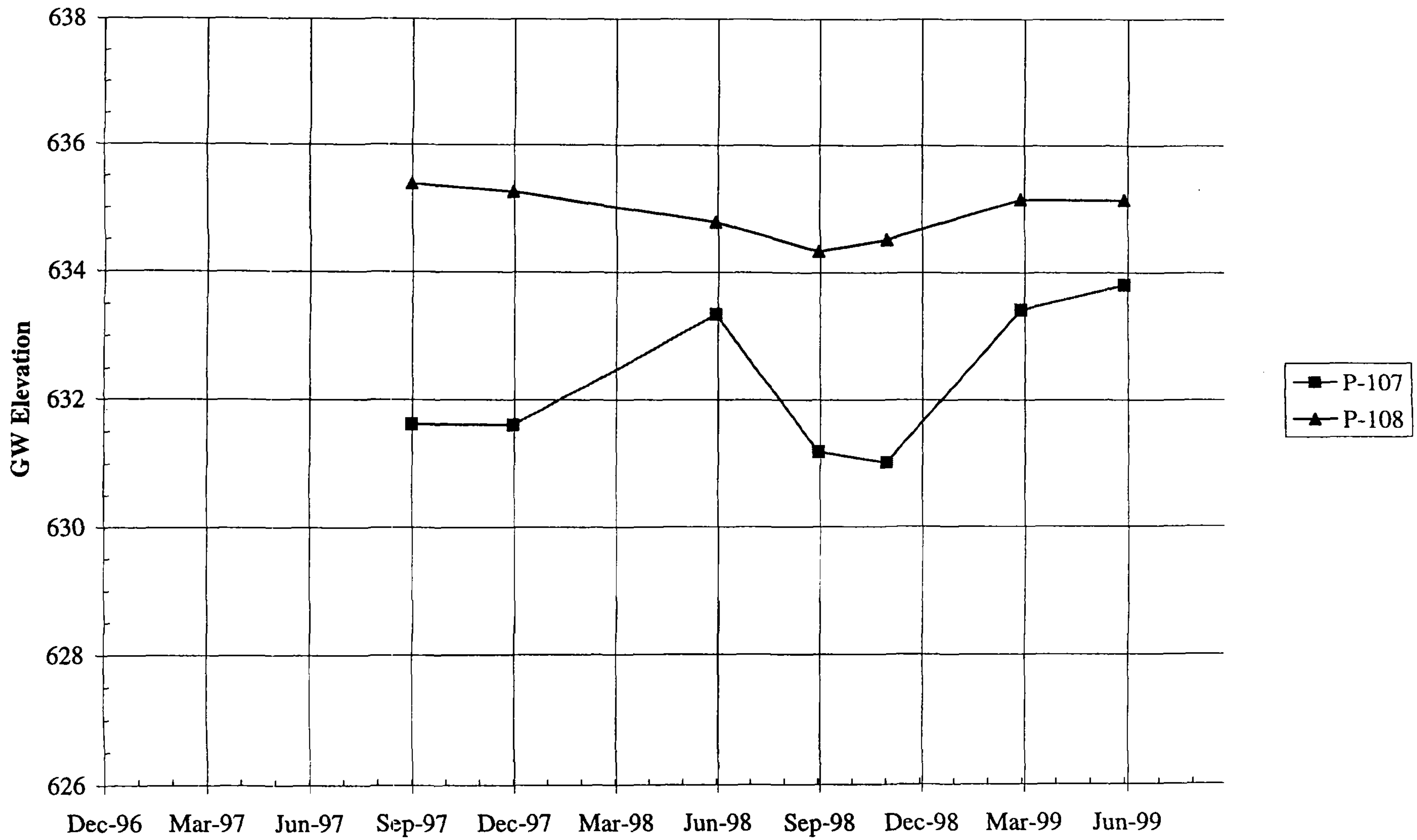


Piezo Pair: P103/P104
638
636
634
632
630
628
626
GW Elevation
Dec-96
Mar-97
Jun-97
Sep-97
Dec-97
Mar-98
Jun-98
Sep-98
Dec-98
Mar-99
Jun-99
P-103
P-104

Piezo Pair: P105/P106



Piezo Pair: P-107/P108



D

HELP MODEL

RESULTS

HELP Model

An evaluation to determine acceptable alternative cap and cover designs for both areas was undertaken using the Hydrologic Evaluation of Landfill Performance (HELP4) Model (7). The model is a two-dimensional iterative hydrological model of water movement across, into, through, and out of impacted soils. The primary purpose of using the HELP model was to demonstrate that the engineered cover designs significantly reduce water infiltration.

Due to the Site's close proximity to Chicago, Illinois, the HELP model's default weather data for Chicago were utilized for the evaluation and were constant for all modeled scenarios. The model simulations assumed "100 percent runoff" over the engineered and surrounding covers. This does not imply that all precipitation runs off the surface, but rather no significant ponding will occur on the covers. Variables for the modeling input included cover design layer-characteristics such as soil and geosynthetic layer types, thickness, surface area, and hydraulic conductivity. A table summarizing the model results includes average annual and daily values of precipitation, runoff, evapotranspiration, and percolation through the cover. Provided within this appendix is the complete model input and output summaries.

HELP Model Results:
SBPA and OFCA Engineered and Surrounding Final Cover Designs
American Chemical Service, Inc. NPL Site
Griffith, Indiana

Engineered and Surrounding Cover Design Description		Average Annual Totals		Peak Daily Values	
		Inches	Cubic Feet	Inches	Cubic Feet
SBPA Engineered Cover	(4" asphalt, 6" compacted gravel, geotextile fabric, 12" compacted clay soil (CL))				
Precipitation		34.15	359,451.80	4.64	48,845.28
Runoff		19.42	204,459.69	4.23	44,573.34
Evapotranspiration		14.52	152,837.83	--	--
Percolation Through Cover		0.21	2,179.20	0.00	47.32
OFCA Engineered Cover	(6" OL, 12" ML, geotextile fabric, 60-mil FML, 12" compacted clay soil (CL))				
Precipitation		34.15	788,314.90	4.64	107,122.75
Runoff		5.17	119,434.30	2.26	52,137.06
Evapotranspiration		28.97	668,743.30	--	--
Percolation Through Cover		0.00005	1.19	0	0.01
OFCA Surrounding Cover	(6"OL, 18"compacted clay soil (CL))				
Precipitation		34.15	1,403,101	4.64	190,665
Runoff		8.03	329,790	3.555	146,065
Evapotranspiration		25.127	1,033,746	--	--
Percolation Through Cover		0.96289	39,567	0.006803	280

JMS/jms/BPG
J:\1252\042\28\Documents\125204228a129.xls
1252042.28350101

SBPA ENGINEERED

COVER

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**                                                                          **
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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**         FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                  **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP3\onsite2\acsrain.D4
TEMPERATURE DATA FILE:        c:\help3\onsite2\acstemp.D7
SOLAR RADIATION DATA FILE:    c:\help3\onsite2\acssun.D13
EVAPOTRANSPIRATION DATA:      c:\help3\onsite2\acsevapo.D11
SOIL AND DESIGN DATA FILE:    c:\help3\onsite2\onsite2.D10
OUTPUT DATA FILE:             c:\help3\onsite2\onsite2.OUT


TIME:  10: 2     DATE:   5/ 5/1999


******************************************************************************

    TITLE:  Onsite final cap - 4" asphalt, 6" gravel, 12" CL

******************************************************************************


    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =       4.00   INCHES
          POROSITY                     =       0.1500 VOL/VOL
          FIELD CAPACITY               =       0.0320 VOL/VOL
          WILTING POINT                =       0.0130 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.1337 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   0.100000001000E-06 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	6.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1451	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.299999993000E-01	CM/SEC

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	98.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	2.900	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.406	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	2.982	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.130	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	6.530	INCHES
TOTAL INITIAL WATER	=	6.530	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM

CHICAGO ILLINOIS

STATION LATITUDE	=	41.78 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	117
END OF GROWING SEASON (JULIAN DATE)	=	290
EVAPORATIVE ZONE DEPTH	=	10.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.60	1.31	2.59	3.66	3.15	4.08
3.63	3.53	3.35	2.28	2.06	2.10

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS
AND STATION LATITUDE = 41.78 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						

TOTALS	1.51	1.36	2.62	3.62	3.12	4.39
	4.02	3.61	3.26	2.35	2.23	2.07
STD. DEVIATIONS	0.65	0.69	1.12	1.58	1.43	2.05
	1.99	1.85	1.76	1.34	1.21	1.03

RUNOFF

TOTALS	0.568	1.333	2.604	2.086	1.554	2.381
	2.140	2.030	1.731	1.185	1.013	0.797
STD. DEVIATIONS	0.682	0.962	1.624	1.267	1.031	1.499
	1.470	1.321	1.293	0.907	0.826	0.782

EVAPOTRANSPIRATION

TOTALS	0.531	0.438	0.704	1.784	1.643	2.086
	1.912	1.583	1.410	0.989	0.860	0.579
STD. DEVIATIONS	0.117	0.101	0.408	0.653	0.517	0.605
	0.646	0.609	0.587	0.446	0.248	0.164

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0451	0.0273	0.0273	0.0263	0.0058	0.0000
	0.0000	0.0000	0.0000	0.0009	0.0188	0.0555
STD. DEVIATIONS	0.0522	0.0430	0.0421	0.0349	0.0195	0.0002
	0.0000	0.0000	0.0000	0.0061	0.0288	0.0496

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.2533	0.1556	0.1111	0.0985	0.0234	0.0000
	0.0000	0.0000	0.0000	0.0016	0.0700	0.2954
STD. DEVIATIONS	0.4177	0.3097	0.2542	0.2954	0.1176	0.0001
	0.0000	0.0000	0.0000	0.0139	0.1616	0.4700

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.15 (5.545)	359451.8	100.00
RUNOFF	19.422 (4.1477)	204459.69	56.881

EVAPOTRANSPIRATION	14.519	(1.6966)	152837.83	42.520
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.20701	(0.17223)	2179.195	0.60626
AVERAGE HEAD ON TOP OF LAYER 3	0.084	(0.116)		
CHANGE IN WATER STORAGE	-0.002	(1.3249)	-24.88	-0.007

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	4.64	48845.281
RUNOFF	4.234	44573.3398
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.004495	47.32199
AVERAGE HEAD ON TOP OF LAYER 3	3.859	
SNOW WATER	7.00	73740.7891

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2183
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0130

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	0.5477	0.1369
2	0.6215	0.1036
3	5.1240	0.4270
SNOW WATER	0.000	

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OFCA ENGINEERED

COVER

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
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TEMPERATURE DATA FILE:       c:\help3\capoff2\acstemp.D7
SOLAR RADIATION DATA FILE:   c:\help3\capoff2\acssun.D13
EVAPOTRANSPIRATION DATA:     c:\help3\capoff2\acsevapo.D11
SOIL AND DESIGN DATA FILE:   c:\help3\capoff2\cap2.D10
OUTPUT DATA FILE:            c:\help3\capoff2\cap2.OUT


TIME:   9:33     DATE:   5/ 5/1999


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    TITLE:  6" OL, 12" ML, 60-mil FML, 12" CL

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    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   6
          THICKNESS                   =       6.00    INCHES
          POROSITY                    =       0.4530 VOL/VOL
          FIELD CAPACITY              =       0.1900 VOL/VOL
          WILTING POINT               =       0.0850 VOL/VOL
          INITIAL SOIL WATER CONTENT  =       0.2916 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.720000011000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9

THICKNESS	=	12.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2840 VOL/VOL
WILTING POINT	=	0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5010 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.190000006000E-03 CM/SEC

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.60 INCHES
POROSITY	=	0.0030 VOL/VOL
FIELD CAPACITY	=	0.0020 VOL/VOL
WILTING POINT	=	0.0010 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0030 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12 CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4049 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 550. FEET.

SCS RUNOFF CURVE NUMBER	=	58.90	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	6.360	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.761	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.730	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.130	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	12.622	INCHES
TOTAL INITIAL WATER	=	12.622	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
CHICAGO ILLINOIS

STATION LATITUDE	=	41.78	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	117	
END OF GROWING SEASON (JULIAN DATE)	=	290	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.60	1.31	2.59	3.66	3.15	4.08
3.63	3.53	3.35	2.28	2.06	2.10

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS
AND STATION LATITUDE = 41.78 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.51	1.36	2.62	3.62	3.12	4.39
	4.02	3.61	3.26	2.35	2.23	2.07
STD. DEVIATIONS	0.65	0.69	1.12	1.58	1.43	2.05
	1.99	1.85	1.76	1.34	1.21	1.03
RUNOFF						
TOTALS	0.229	0.795	2.060	1.152	0.165	0.135
	0.052	0.023	0.018	0.100	0.148	0.298
STD. DEVIATIONS	0.395	0.719	1.650	1.337	0.477	0.433
	0.283	0.226	0.142	0.485	0.506	0.569
EVAPOTRANSPIRATION						
TOTALS	0.532	0.444	0.750	2.946	3.669	6.636
	5.254	3.807	2.313	1.188	0.861	0.566
STD. DEVIATIONS	0.115	0.102	0.457	0.736	1.013	0.558
	1.917	1.751	0.964	0.216	0.185	0.151
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0004	0.0003	0.0004	0.0004	0.0004	0.0004
	0.0002	0.0001	0.0001	0.0002	0.0003	0.0003
STD. DEVIATIONS	0.0009	0.0008	0.0008	0.0007	0.0007	0.0006
	0.0004	0.0002	0.0003	0.0005	0.0006	0.0006

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	6.5733	3.3089	5.1159	12.5160	12.8146	8.6053
	2.7410	0.9653	1.0326	2.5158	5.2901	8.3112
STD. DEVIATIONS	4.7424	2.3561	3.9895	3.5484	1.8554	2.7431
	3.7324	2.3750	2.9180	4.6420	5.7652	6.2616

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	34.15	(5.545)	788314.9	100.00
RUNOFF	5.173	(2.6131)	119434.30	15.151
EVAPOTRANSPIRATION	28.967	(3.6080)	668743.81	84.832
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00005	(0.00002)	1.192	0.00015
AVERAGE HEAD ON TOP OF LAYER 3	5.816	(1.950)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00337	(0.00664)	77.915	0.00988
CHANGE IN WATER STORAGE	0.003	(2.6493)	58.90	0.007

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	4.64	107122.750
RUNOFF	2.258	52137.0625
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000000	0.00974
AVERAGE HEAD ON TOP OF LAYER 3	18.000	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000261	6.02150
SNOW WATER	7.00	161721.1720
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4850	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1183	

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	2.7180	0.4530
2	5.6308	0.4692
3	0.0018	0.0030
4	4.5263	0.3772
SNOW WATER	0.000	

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OFCA SURROUNDING

COVER

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP3\offcov2\acsrain.D4
TEMPERATURE DATA FILE:        c:\help3\offcov2\acstemp.D7
SOLAR RADIATION DATA FILE:    c:\help3\offcov2\acssun.D13
EVAPOTRANSPIRATION DATA:      c:\help3\offcov2\acsevapo.D11
SOIL AND DESIGN DATA FILE:    c:\help3\offcov2\offcov2#.D10
OUTPUT DATA FILE:             c:\help3\offcov2\offsite.OUT


TIME:   9:42      DATE:   5/ 5/1999


******************************************************************************

     TITLE:  offsite cover

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   6
          THICKNESS                    =       6.00  INCHES
          POROSITY                     =     0.4530 VOL/VOL
          FIELD CAPACITY               =     0.1900 VOL/VOL
          WILTING POINT                =     0.0850 VOL/VOL
          INITIAL SOIL WATER CONTENT   =     0.4530 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.720000011000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4241	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 800. FEET.

SCS RUNOFF CURVE NUMBER	=	57.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	11.320	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.263	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.280	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.712	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	10.387	INCHES
TOTAL INITIAL WATER	=	10.387	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
CHICAGO ILLINOIS

STATION LATITUDE	=	41.78 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	117
END OF GROWING SEASON (JULIAN DATE)	=	290
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.60	1.31	2.59	3.66	3.15	4.08
3.63	3.53	3.35	2.28	2.06	2.10

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS
AND STATION LATITUDE = 41.78 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.51	1.36	2.62	3.62	3.12	4.39
	4.02	3.61	3.26	2.35	2.23	2.07
STD. DEVIATIONS	0.65	0.69	1.12	1.58	1.43	2.05
	1.99	1.85	1.76	1.34	1.21	1.03
RUNOFF						
TOTALS	0.413	1.168	2.553	1.324	0.181	0.231
	0.212	0.166	0.296	0.285	0.575	0.622
STD. DEVIATIONS	0.609	0.877	1.649	1.374	0.492	0.617
	0.597	0.561	0.749	0.727	0.893	0.812
EVAPOTRANSPIRATION						
TOTALS	0.532	0.437	0.766	2.959	3.491	4.327
	3.867	3.408	2.327	1.417	1.026	0.601
STD. DEVIATIONS	0.117	0.103	0.501	0.768	1.014	1.356
	1.552	1.491	0.986	0.329	0.206	0.178
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0062	0.0009	0.0367	0.1519	0.1642	0.0561
	0.0438	0.0447	0.0598	0.1311	0.1539	0.1134
STD. DEVIATIONS	0.0165	0.0027	0.0488	0.0421	0.0191	0.0421
	0.0424	0.0416	0.0578	0.0699	0.0647	0.0626

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.1903	0.0184	1.8883	7.8406	7.0512	2.3474
	1.8712	1.9239	2.7930	6.3122	8.1537	5.3843
STD. DEVIATIONS	0.6770	0.1528	2.6314	2.2568	1.4546	2.0414
	1.9887	1.9303	2.9465	3.7932	3.8824	3.4167

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.15 (5.545)	1403101.4	100.00
RUNOFF	8.026 (3.0241)	329789.53	23.504
EVAPOTRANSPIRATION	25.157 (3.3601)	1033745.56	73.676
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.96289 (0.22833)	39566.805	2.81995
AVERAGE HEAD ON TOP OF LAYER 3	3.815 (1.042)		
CHANGE IN WATER STORAGE	0.000 (1.4783)	-0.23	0.000

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	4.64	190665.016
RUNOFF	3.555	146065.1250
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.006803	279.55014
AVERAGE HEAD ON TOP OF LAYER 3	12.000	
SNOW WATER	7.00	287843.3440

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4400
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2260

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	2.7180	0.4530
2	2.5440	0.4240
3	5.1240	0.4270
SNOW WATER	0.000	

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Channel

Design

Channel Design

The Haestad Flowmaster™ computer model was employed to design perimeter channels for the OFCA that could adequately handle peak discharge flow rates. Peak discharge rate estimates were based on a 100-year, 24-hour storm event with a maximum rainfall amount of seven inches and were calculated by the TR-55 Model. As a result of this evaluation, the maximum allowable flow was calculated for each open trapezoidal-shape channel using Manning's formula. The following input parameters were used in this evaluation:

- Manning's coefficient;
- Channel slope;
- Channel depth; and
- Channel dimensions.

The aforementioned variables were used in conjunction with the TR-55 peak flow discharge rates from each watershed area to design trapezoidal-shape passageways capable of withstanding these calculated maximum flows. However, some OFCA perimeter channels will receive cumulative flow from connecting channels and watershed areas. This was taken into consideration during the design process in establishing appropriate channel dimensions. Provided are the worksheets, rating tables, plotted curves, and cross-sections associated with each channel. Manning's coefficients yielded curve plot comparisons for trapezoidal-shape channels. The performance curves were used as a tool to determine an acceptable discharge channel dimensions based on flow carrying capabilities. The varying Manning's coefficient was necessary due to variability and uncertainty of vegetative or rock being placed in the channels. Also provided is a table summarizing the data results from the Haestad Flowmaster™ computer model.

Table xx. Summary of Data Results for Designed Trapezoidal Channels

American Chemical Services

Channel Numbers	Drainage Area (acres)	Channel Slope (ft/ft)	Channel Depth (ft)	Channel Dimensions: Left Side Slope H:V	Channel Dimensions: Right Side Slope H:V	Channel Base (ft)	Channel Velocity (ft/s)	Peak Discharge Entering Channel (cfs)	Maximum Flow in Channel (cfs)	Manning's Coefficient --
1	4.25	0.015	1.0	4.0	4.0	2	4.10	13	24.58	0.035
2	3.31	0.015	1.0	4.0	4.0	2	4.25	14	25.48	0.030
3	1.78	0.019	1.0	4.0	4.0	2	4.10	7	24.58	0.035
4A	0.28	0.019	1.0	4.0	4.0	2	4.78	8	28.67	0.030
4B	2.36	0.019	1.0	4.0	4.0	2	5.44	31	47.59	0.030

Notes:

1) OFCA partitioned into six watershed sections
2) Channels 2, 4A, and 4B Manning's Coefficient represents short grass and few weeds
3) Channels 1 and 3 Manning's Coefficient represents rock based on design section
4) Peak discharge entering channel based on 100 year, 24 hour storm event

Channel No. 1 - Design Sheet

ACS_OFCA_CHANNEL_01
Worksheet for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_01.fm2
Worksheet	ACS_OFCA_CHANNEL_01
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.035	
Channel Slope	0.019000	ft/ft
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Results		
Discharge	24.58	cfs
Flow Area	6.00	ft^2
Wetted Perimeter	10.25	ft
Top Width	10.00	ft
Critical Depth	0.97	ft
Critical Slope	0.022069	ft/ft
Velocity	4.10	ft/s
Velocity Head	0.26	ft
Specific Energy	1.26	ft
Froude Number	0.93	
Flow is subcritical.		

ACS_OFCA_CHANNEL01
Rating Table for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_01.fm2
Worksheet	ACS_OFCA_CHANNEL_01
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Input Data	Minimum	Maximum	Increment
Mannings Coefficient	0.025	0.045	0.005
Channel Slope	0.015100	0.023000	0.001000 ft/ft

Rating Table

Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.015100	0.025	30.67	5.11
0.015100	0.030	25.56	4.26
0.015100	0.035	21.91	3.65
0.015100	0.040	19.17	3.20
0.015100	0.045	17.04	2.84
0.016100	0.025	31.67	5.28
0.016100	0.030	26.39	4.40
0.016100	0.035	22.62	3.77
0.016100	0.040	19.80	3.30
0.016100	0.045	17.60	2.93
0.017100	0.025	32.64	5.44
0.017100	0.030	27.20	4.53
0.017100	0.035	23.31	3.89
0.017100	0.040	20.40	3.40
0.017100	0.045	18.13	3.02
0.018100	0.025	33.58	5.60
0.018100	0.030	27.98	4.66
0.018100	0.035	23.99	4.00
0.018100	0.040	20.99	3.50
0.018100	0.045	18.66	3.11
0.019100	0.025	34.50	5.75
0.019100	0.030	28.75	4.79
0.019100	0.035	24.64	4.11

ACS_OFCA_CHANNEL01
Rating Table for Trapezoidal Channel

Rating Table

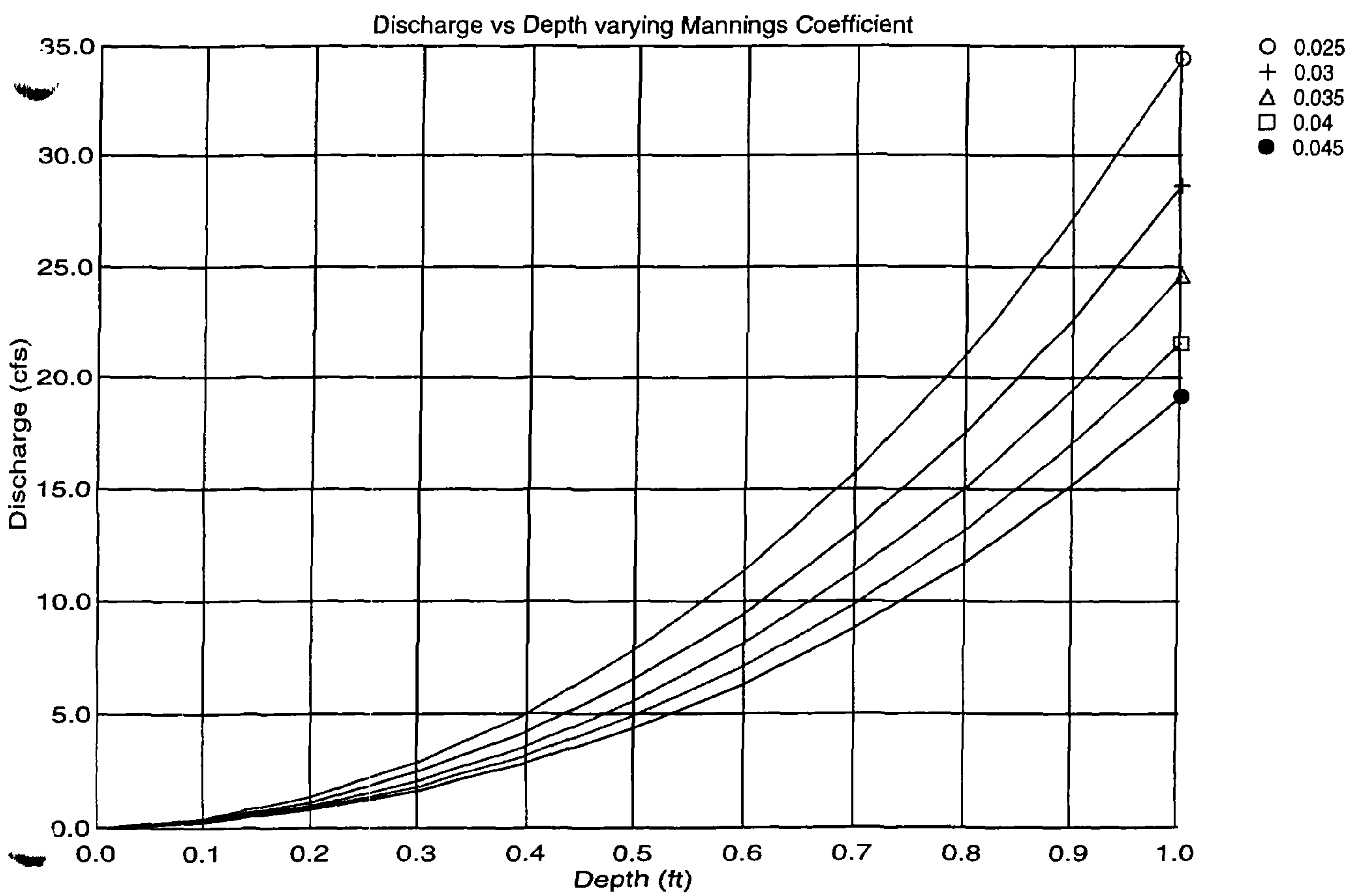
Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.019100	0.040	21.56	3.59
0.019100	0.045	19.17	3.19
0.020100	0.025	35.39	5.90
0.020100	0.030	29.49	4.92
0.020100	0.035	25.28	4.21
0.020100	0.040	22.12	3.69
0.020100	0.045	19.66	3.28
0.021100	0.025	36.26	6.04
0.021100	0.030	30.22	5.04
0.021100	0.035	25.90	4.32
0.021100	0.040	22.66	3.78
0.021100	0.045	20.14	3.36
0.022100	0.025	37.11	6.18
0.022100	0.030	30.92	5.15
0.022100	0.035	26.51	4.42
0.022100	0.040	23.19	3.87
0.022100	0.045	20.62	3.44
0.023100	0.025	37.94	6.32
0.023100	0.030	31.61	5.27
0.023100	0.035	27.10	4.52
0.023100	0.040	23.71	3.95
0.023100	0.045	21.08	3.51

ACS_OFCA_CHANNEL01
Plotted Curves for Trapezoidal Channel

Project Description	
Project File	*j:\1252\042\28\documents\cap model files\off_01.fm2*
Worksheet	ACS_OFCA_CHANNEL_01
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Channel Slope	0.019000	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

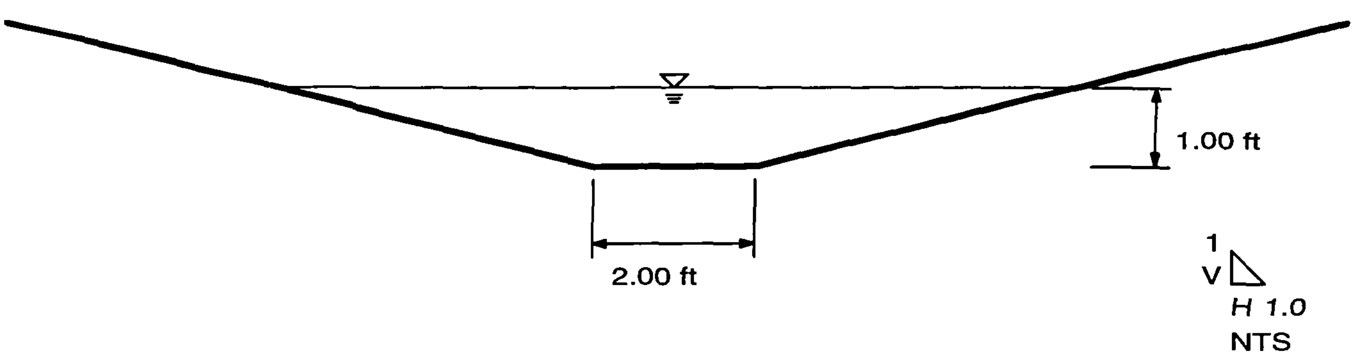
Input Data	Minimum	Maximum	Increment	
Depth	0.00	1.00	0.10	ft
Mannings Coefficient	0.025	0.045	0.005	



ACS_OFCA_CHANNEL01_Cross Section
Cross Section for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_01.fm2
Worksheet	ACS_OFCA_CHANNEL_01
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Mannings Coefficient	0.035	
Channel Slope	0.019000	ft/ft
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft
Discharge	24.58	cfs



Channel No. 2 - Design Sheet

ACS_OFCA_CHANNEL02
Worksheet for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_02.fm2
Worksheet	ACS_OFCA_CHANNEL02
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.015000	ft/ft
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Results		
Discharge	25.48	cfs
Flow Area	6.00	ft^2
Wetted Perimeter	10.25	ft
Top Width	10.00	ft
Critical Depth	0.98	ft
Critical Slope	0.016136	ft/ft
Velocity	4.25	ft/s
Velocity Head	0.28	ft
Specific Energy	1.28	ft
Froude Number	0.97	
Flow is subcritical.		

ACS_OFCA_CHANNEL02
Rating Table for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_02.fm2
Worksheet	ACS_OFCA_CHANNEL02
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Input Data	Minimum	Maximum	Increment
Mannings Coefficient	0.020	0.040	0.005
Channel Slope	0.011000	0.019000	0.001000 ft/ft

Rating Table

Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.011000	0.020	32.72	5.45
0.011000	0.025	26.18	4.36
0.011000	0.030	21.82	3.64
0.011000	0.035	18.70	3.12
0.011000	0.040	16.36	2.73
0.012000	0.020	34.18	5.70
0.012000	0.025	27.34	4.56
0.012000	0.030	22.79	3.80
0.012000	0.035	19.53	3.26
0.012000	0.040	17.09	2.85
0.013000	0.020	35.58	5.93
0.013000	0.025	28.46	4.74
0.013000	0.030	23.72	3.95
0.013000	0.035	20.33	3.39
0.013000	0.040	17.79	2.96
0.014000	0.020	36.92	6.15
0.014000	0.025	29.53	4.92
0.014000	0.030	24.61	4.10
0.014000	0.035	21.10	3.52
0.014000	0.040	18.46	3.08
0.015000	0.020	38.21	6.37
0.015000	0.025	30.57	5.10
0.015000	0.030	25.48	4.25

ACS_OFCA_CHANNEL02
Rating Table for Trapezoidal Channel

Rating Table

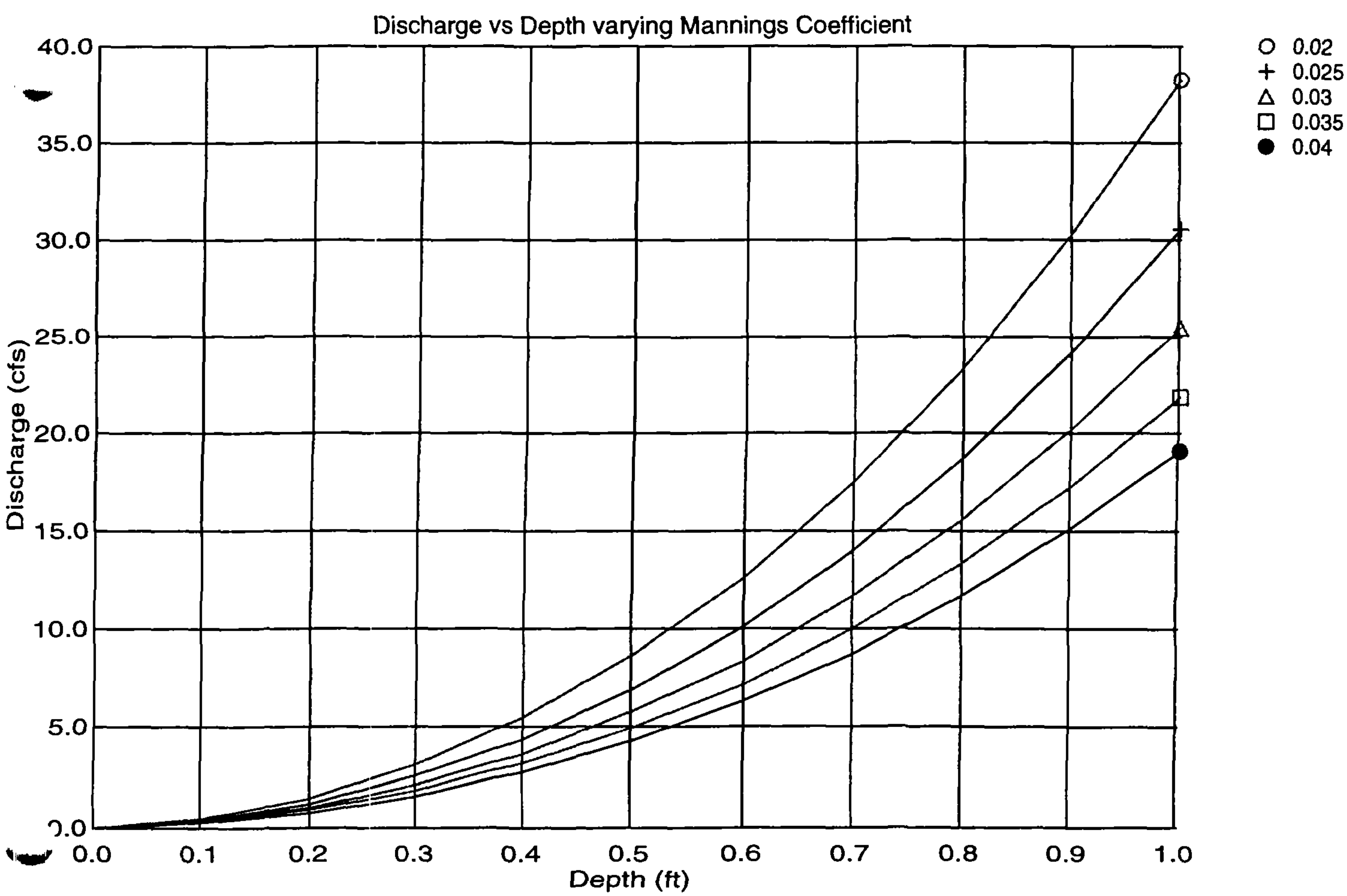
Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.015000	0.035	21.84	3.64
0.015000	0.040	19.11	3.18
0.016000	0.020	39.47	6.58
0.016000	0.025	31.57	5.26
0.016000	0.030	26.31	4.39
0.016000	0.035	22.55	3.76
0.016000	0.040	19.73	3.29
0.017000	0.020	40.68	6.78
0.017000	0.025	32.55	5.42
0.017000	0.030	27.12	4.52
0.017000	0.035	23.25	3.87
0.017000	0.040	20.34	3.39
0.018000	0.020	41.86	6.98
0.018000	0.025	33.49	5.58
0.018000	0.030	27.91	4.65
0.018000	0.035	23.92	3.99
0.018000	0.040	20.93	3.49
0.019000	0.020	43.01	7.17
0.019000	0.025	34.41	5.73
0.019000	0.030	28.67	4.78
0.019000	0.035	24.58	4.10
0.019000	0.040	21.50	3.58

ACS_OFCA_CHANNEL02
Plotted Curves for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_02.fm2
Worksheet	ACS_OFCA_CHANNEL02
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Channel Slope	0.015000	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

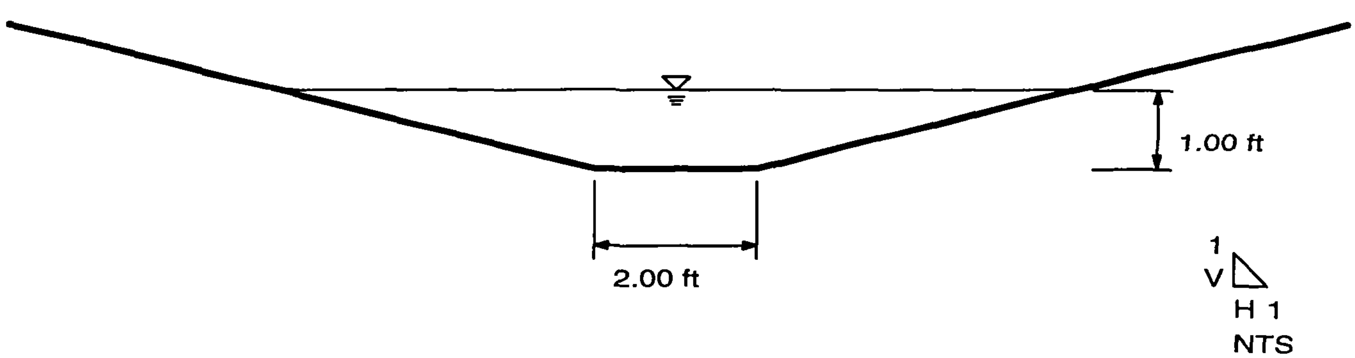
Input Data	Minimum	Maximum	Increment	
Depth	0.00	1.00	0.10	ft
Mannings Coefficient	0.020	0.040	0.005	



ACS_OFCA_CHANNEL02_Cross Section
Cross Section for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_02.fm2
Worksheet	ACS_OFCA_CHANNEL02
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Mannings Coefficient	0.030	
Channel Slope	0.015000	ft/ft
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft
Discharge	25.48	cfs



Channel No. 3 - Design Sheet

ACS_OFCA_CHANNEL03
Worksheet for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_03.fm2
Worksheet	ACS_OFCA_CHANNEL03
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

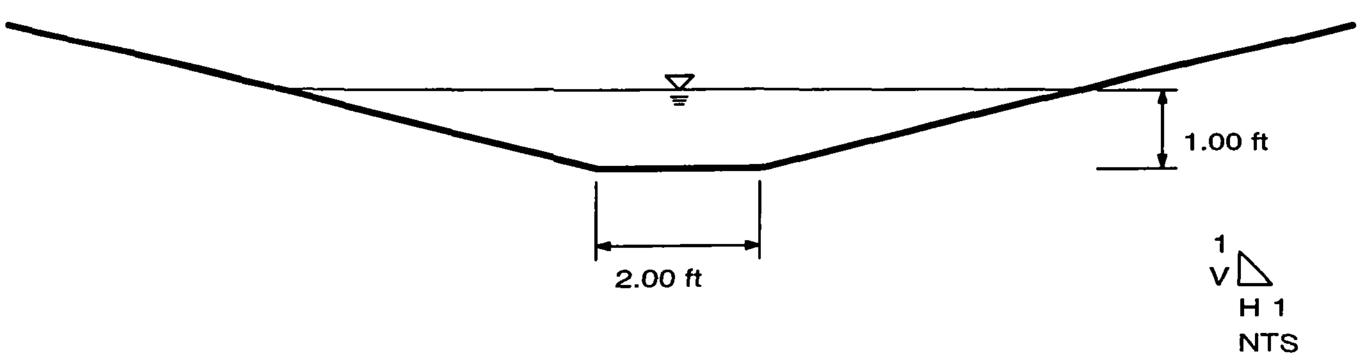
Input Data		
Mannings Coefficient	0.035	
Channel Slope	0.019000	ft/ft
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Results		
Discharge	24.58	cfs
Flow Area	6.00	ft^2
Wetted Perimeter	10.25	ft
Top Width	10.00	ft
Critical Depth	0.97	ft
Critical Slope	0.022069	ft/ft
Velocity	4.10	ft/s
Velocity Head	0.26	ft
Specific Energy	1.26	ft
Froude Number	0.93	
Flow is subcritical.		

ACS_OFCA_CHANNEL03_Cross Section
Cross Section for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_03.fm2
Worksheet	ACS_OFCA_CHANNEL03
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Mannings Coefficient	0.035	
Channel Slope	0.019000	ft/ft
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft
Discharge	24.58	cfs

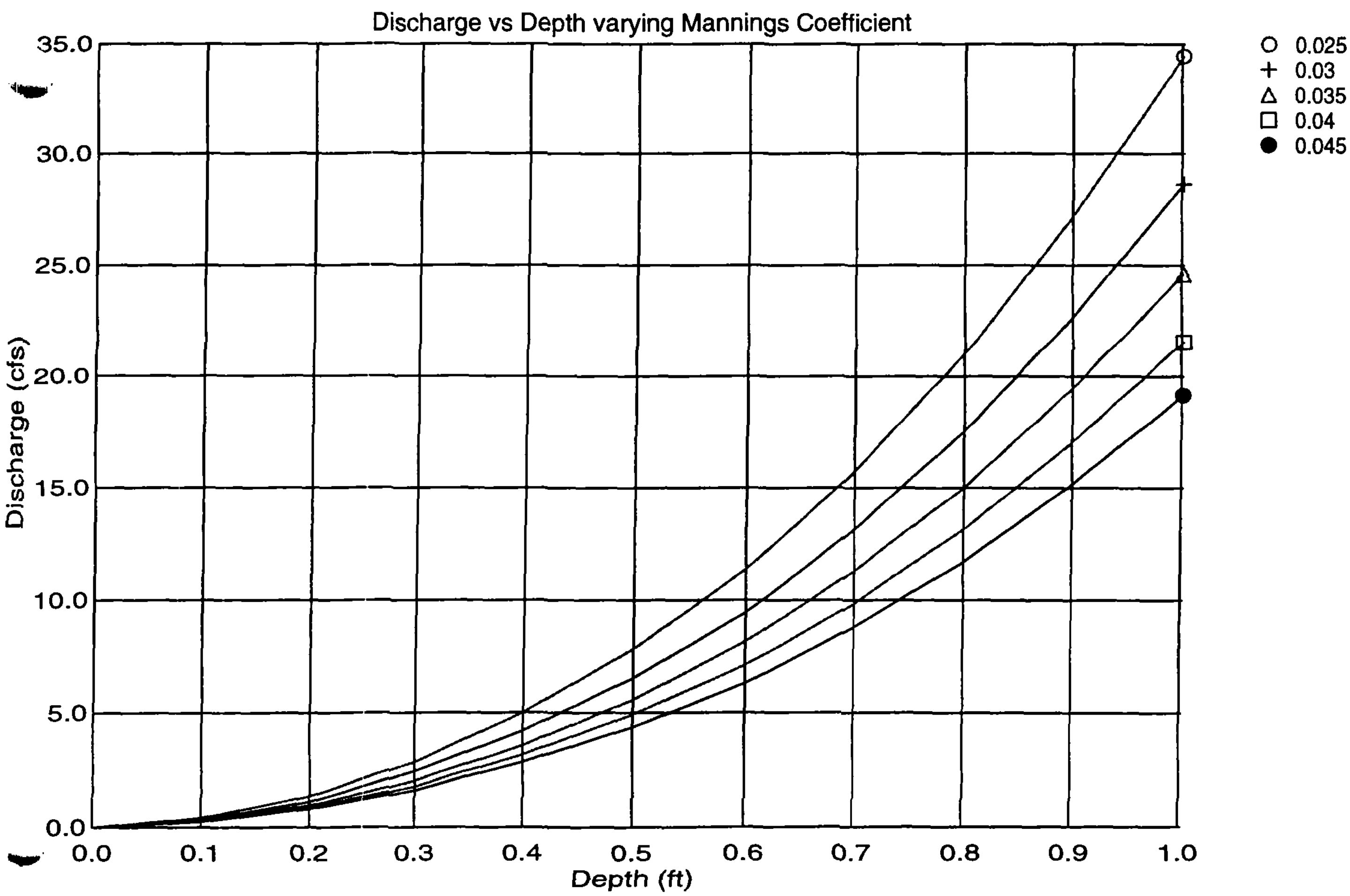


ACS_OFCA_CHANNEL03
Plotted Curves for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_03.fm2
Worksheet	ACS_OFCA_CHANNEL03
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Channel Slope	0.019000	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Input Data	Minimum	Maximum	Increment	
Depth	0.00	1.00	0.10	ft
Mannings Coefficient	0.025	0.045	0.005	



ACS_OFCA_CHANNEL03
Rating Table for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_03.fm2
Worksheet	ACS_OFCA_CHANNEL03
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Input Data	Minimum	Maximum	Increment
Mannings Coefficient	0.025	0.045	0.010
Channel Slope	0.015000	0.023000	0.001000 ft/ft

Rating Table

Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.015000	0.025	30.57	5.10
0.015000	0.035	21.84	3.64
0.015000	0.045	16.98	2.83
0.016000	0.025	31.57	5.26
0.016000	0.035	22.55	3.76
0.016000	0.045	17.54	2.92
0.017000	0.025	32.55	5.42
0.017000	0.035	23.25	3.87
0.017000	0.045	18.08	3.01
0.018000	0.025	33.49	5.58
0.018000	0.035	23.92	3.99
0.018000	0.045	18.60	3.10
0.019000	0.025	34.41	5.73
0.019000	0.035	24.58	4.10
0.019000	0.045	19.11	3.19
0.020000	0.025	35.30	5.88
0.020000	0.035	25.21	4.20
0.020000	0.045	19.61	3.27
0.021000	0.025	36.17	6.03
0.021000	0.035	25.84	4.31
0.021000	0.045	20.10	3.35
0.022000	0.025	37.02	6.17
0.022000	0.035	26.45	4.41

ACS_OFCA_CHANNEL03
Rating Table for Trapezoidal Channel

Rating Table

Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.022000	0.045	20.57	3.43
0.023000	0.025	37.86	6.31
0.023000	0.035	27.04	4.51
0.023000	0.045	21.03	3.51

Channel No. 4A - Design Sheet

ACS_OFCA_CHANNEL04
Worksheet for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_04a.fm2
Worksheet	ACS_OFCA_CHANNEL04A
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.019000	ft/ft
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Results		
Discharge	28.67	cfs
Flow Area	6.00	ft^2
Wetted Perimeter	10.25	ft
Top Width	10.00	ft
Critical Depth	1.04	ft
Critical Slope	0.015881	ft/ft
Velocity	4.78	ft/s
Velocity Head	0.35	ft
Specific Energy	1.35	ft
Froude Number	1.09	
Flow is supercritical.		

ACS_OFCA_CHANNEL04A
Rating Table for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_04a.fm2
Worksheet	ACS_OFCA_CHANNEL04A
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Input Data	Minimum	Maximum	Increment
Mannings Coefficient	0.020	0.040	0.005
Channel Slope	0.015000	0.023000	0.001000 ft/ft

Rating Table

Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.015000	0.020	38.21	6.37
0.015000	0.025	30.57	5.10
0.015000	0.030	25.48	4.25
0.015000	0.035	21.84	3.64
0.015000	0.040	19.11	3.18
0.016000	0.020	39.47	6.58
0.016000	0.025	31.57	5.26
0.016000	0.030	26.31	4.39
0.016000	0.035	22.55	3.76
0.016000	0.040	19.73	3.29
0.017000	0.020	40.68	6.78
0.017000	0.025	32.55	5.42
0.017000	0.030	27.12	4.52
0.017000	0.035	23.25	3.87
0.017000	0.040	20.34	3.39
0.018000	0.020	41.86	6.98
0.018000	0.025	33.49	5.58
0.018000	0.030	27.91	4.65
0.018000	0.035	23.92	3.99
0.018000	0.040	20.93	3.49
0.019000	0.020	43.01	7.17
0.019000	0.025	34.41	5.73
0.019000	0.030	28.67	4.78

ACS_OFCA_CHANNEL04A
Rating Table for Trapezoidal Channel

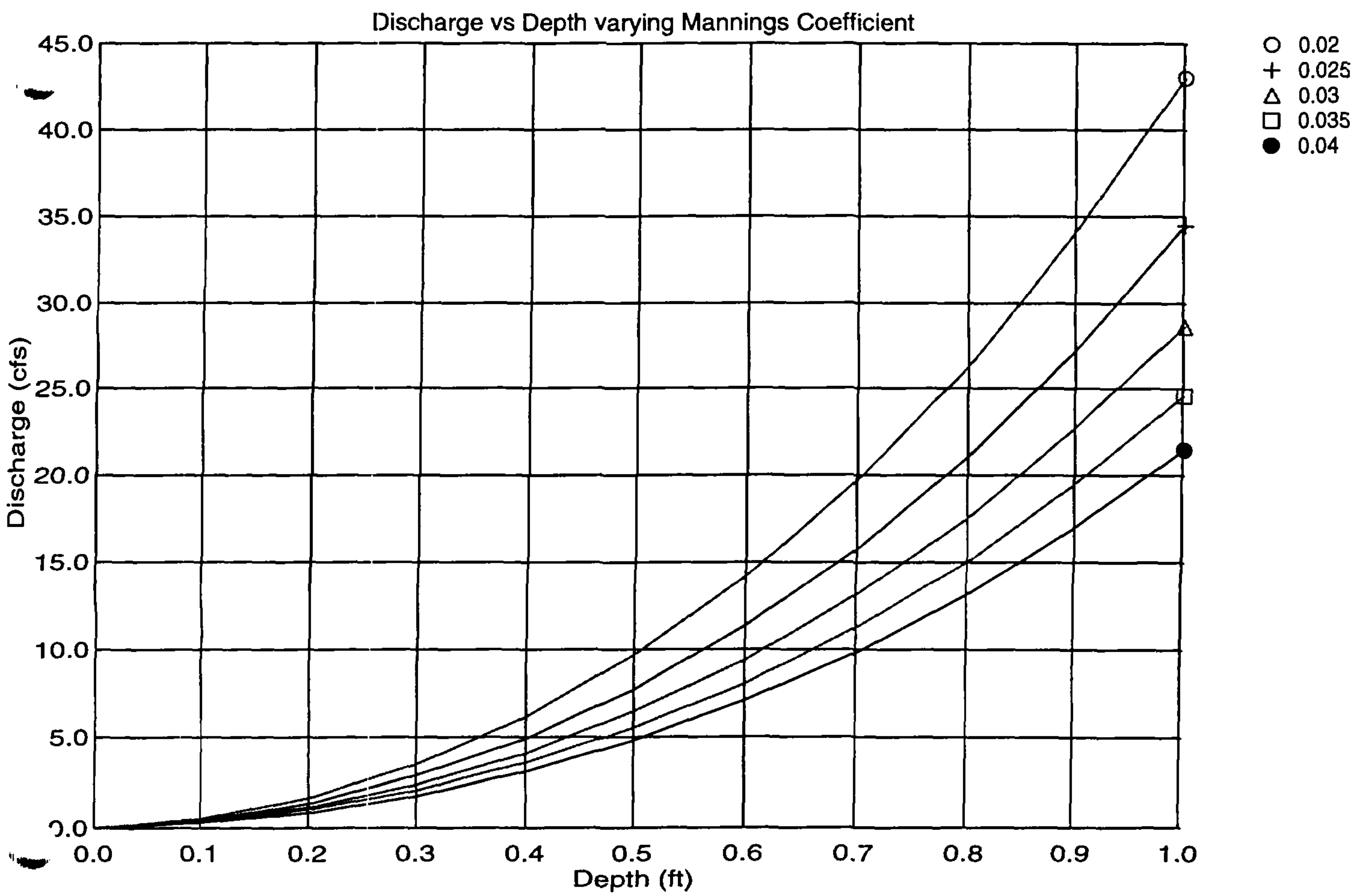
Rating Table Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.019000	0.035	24.58	4.10
0.019000	0.040	21.50	3.58
0.020000	0.020	44.13	7.35
0.020000	0.025	35.30	5.88
0.020000	0.030	29.42	4.90
0.020000	0.035	25.21	4.20
0.020000	0.040	22.06	3.68
0.021000	0.020	45.22	7.54
0.021000	0.025	36.17	6.03
0.021000	0.030	30.14	5.02
0.021000	0.035	25.84	4.31
0.021000	0.040	22.61	3.77
0.022000	0.020	46.28	7.71
0.022000	0.025	37.02	6.17
0.022000	0.030	30.85	5.14
0.022000	0.035	26.45	4.41
0.022000	0.040	23.14	3.86
0.023000	0.020	47.32	7.89
0.023000	0.025	37.86	6.31
0.023000	0.030	31.55	5.26
0.023000	0.035	27.04	4.51
0.023000	0.040	23.66	3.94

ACS_OFCA_CHANNEL04A
Plotted Curves for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_04a.fm2
Worksheet	ACS_OFCA_CHANNEL04A
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Channel Slope	0.019000	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

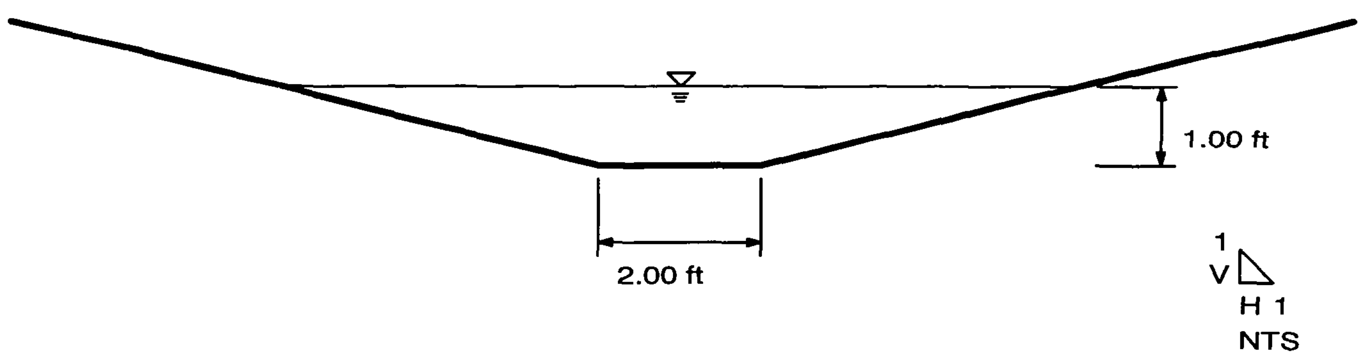
Input Data	Minimum	Maximum	Increment	
Depth	0.00	1.00	0.10	ft
Mannings Coefficient	0.020	0.040	0.005	



ACS_OFCA_CHANNEL04A_Cross Section
Cross Section for Trapezoidal Channel

Project Description	
Project File	*j:\1252\042\28\documents\cap model files\off_04a.fm2*
Worksheet	ACS_OFCA_CHANNEL04A
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Mannings Coefficient	0.030	
Channel Slope	0.019000	ft/ft
Depth	1.00	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft
Discharge	28.67	cfs



Channel No. 4B - Design Sheet

ACS_OFCA_CHANNEL04B
Worksheet for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_04b.fm2
Worksheet	ACS_OFCA_CHANNEL04B
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.019000	ft/ft
Depth	1.25	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Results		
Discharge	47.59	cfs
Flow Area	8.75	ft^2
Wetted Perimeter	12.31	ft
Top Width	12.00	ft
Critical Depth	1.32	ft
Critical Slope	0.014840	ft/ft
Velocity	5.44	ft/s
Velocity Head	0.46	ft
Specific Energy	1.71	ft
Froude Number	1.12	
Flow is supercritical.		

ACS_OFCA_CHANNEL04B
Rating Table for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_04b.fm2
Worksheet	ACS_OFCA_CHANNEL04B
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Depth	1.25	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

Input Data	Minimum	Maximum	Increment
Mannings Coefficient	0.020	0.040	0.005
Channel Slope	0.015000	0.023000	0.001000 ft/ft

Rating Table

Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.015000	0.020	63.42	7.25
0.015000	0.025	50.74	5.80
0.015000	0.030	42.28	4.83
0.015000	0.035	36.24	4.14
0.015000	0.040	31.71	3.62
0.016000	0.020	65.50	7.49
0.016000	0.025	52.40	5.99
0.016000	0.030	43.67	4.99
0.016000	0.035	37.43	4.28
0.016000	0.040	32.75	3.74
0.017000	0.020	67.52	7.72
0.017000	0.025	54.01	6.17
0.017000	0.030	45.01	5.14
0.017000	0.035	38.58	4.41
0.017000	0.040	33.76	3.86
0.018000	0.020	69.48	7.94
0.018000	0.025	55.58	6.35
0.018000	0.030	46.32	5.29
0.018000	0.035	39.70	4.54
0.018000	0.040	34.74	3.97
0.019000	0.020	71.38	8.16
0.019000	0.025	57.10	6.53
0.019000	0.030	47.59	5.44

ACS_OFCA_CHANNEL04B
Rating Table for Trapezoidal Channel

Rating Table

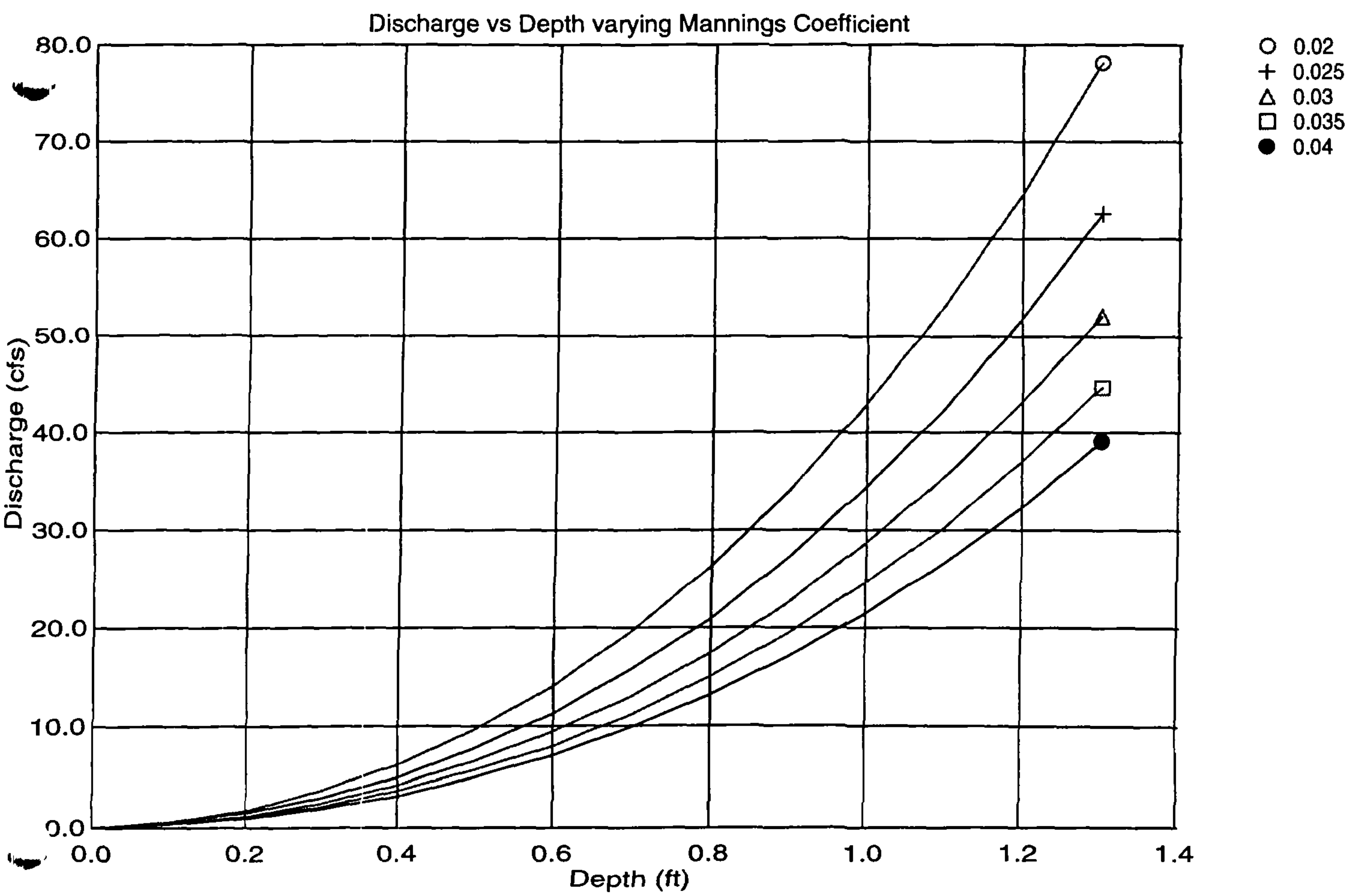
Channel Slope (ft/ft)	Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
0.019000	0.035	40.79	4.66
0.019000	0.040	35.69	4.08
0.020000	0.020	73.23	8.37
0.020000	0.025	58.59	6.70
0.020000	0.030	48.82	5.58
0.020000	0.035	41.85	4.78
0.020000	0.040	36.62	4.18
0.021000	0.020	75.04	8.58
0.021000	0.025	60.03	6.86
0.021000	0.030	50.03	5.72
0.021000	0.035	42.88	4.90
0.021000	0.040	37.52	4.29
0.022000	0.020	76.81	8.78
0.022000	0.025	61.45	7.02
0.022000	0.030	51.21	5.85
0.022000	0.035	43.89	5.02
0.022000	0.040	38.40	4.39
0.023000	0.020	78.53	8.98
0.023000	0.025	62.83	7.18
0.023000	0.030	52.36	5.98
0.023000	0.035	44.88	5.13
0.023000	0.040	39.27	4.49

ACS_OFCA_CHANNEL04B
Plotted Curves for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_04b.fm2
Worksheet	ACS_OFCA_CHANNEL04B
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Channel Slope	0.019000	ft/ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft

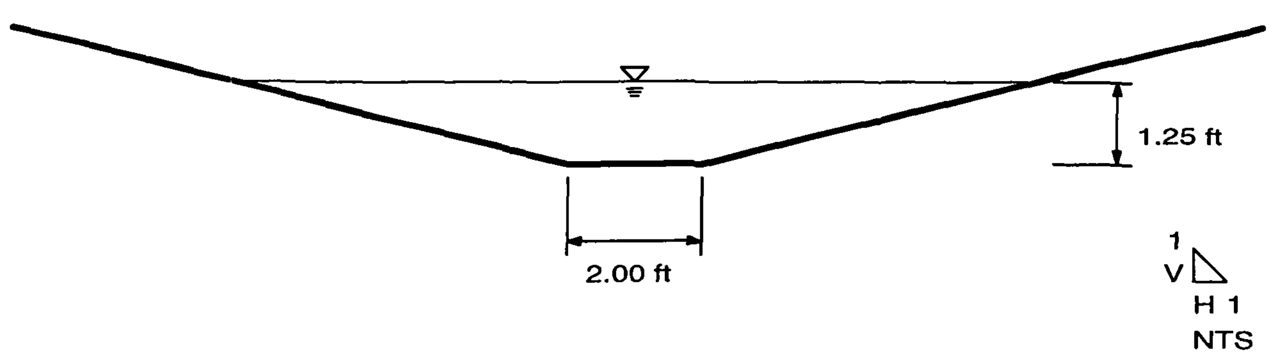
Input Data	Minimum	Maximum	Increment	
Depth	0.00	1.25	0.10	ft
Mannings Coefficient	0.020	0.040	0.005	



ACS_OFCA_CHANNEL04B_Cross Section
Cross Section for Trapezoidal Channel

Project Description	
Project File	j:\1252\042\28\documents\cap model files\off_04b.fm2
Worksheet	ACS_OFCA_CHANNEL04B
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Mannings Coefficient	0.030	
Channel Slope	0.019000	ft/ft
Depth	1.25	ft
Left Side Slope	4.000000	H : V
Right Side Slope	4.000000	H : V
Bottom Width	2.00	ft
Discharge	47.59	cfs



TR-55 MODEL

RESULTS

TR55-Model Results

Drainage calculations were conducted for both of the OFCA and SBPA final covers to determine stormwater runoff flow. Both final covers were partitioned into sections to estimate the peak discharge rate entering the OFCA perimeter channels and the SBPA stormwater collection system. Peak watershed estimates were based on a 100-year, 24-hour storm event with a maximum rainfall amount of seven inches. The Technical Release-55 (TR-55) computer model was employed to predict the time of concentration and time traveled. These output parameters represent the amount of runoff time traveled from the hydraulically most distant point of the watershed and the time it takes water to travel from location to another in the watershed, respectively. Additional input parameters include the following:

- Watershed travel length to channel or catch basin;
- Surface area;
- SCS runoff curve number representing the surficial layer;
- Slope of each flow patch;
- Manning's roughness coefficient;
- Rainfall amount for a two-year, 24-hour storm event;
- Length, cross sectional area, and wetted perimeter of each channel; and
- Slope of channel.

OFCA

The OFCA engineered cover will consist of a highly vegetated surface of shallow-rooted grass that will direct surface water towards the designed trapezoidal-shape perimeter channels. The OFCA was partitioned into six sections based on the final design contours of the engineered cover. A sketch diagram has been provided illustrating the partitioning of the final cover. This approach was undertaken to provide an acceptable estimate of the peak discharge rate that flowing towards the perimeter channels during this specific rainfall event. A table provided below summarizes the peak discharge rate from each partitioned area.

Partitioned Area	Approximate Size (acres)	Peak Discharge Rate (cfs)
1	4.25	13
2	2.02	7
3	3.31	14
4	1.78	7
5A	0.28	1
5B	0.34	2

SBPA

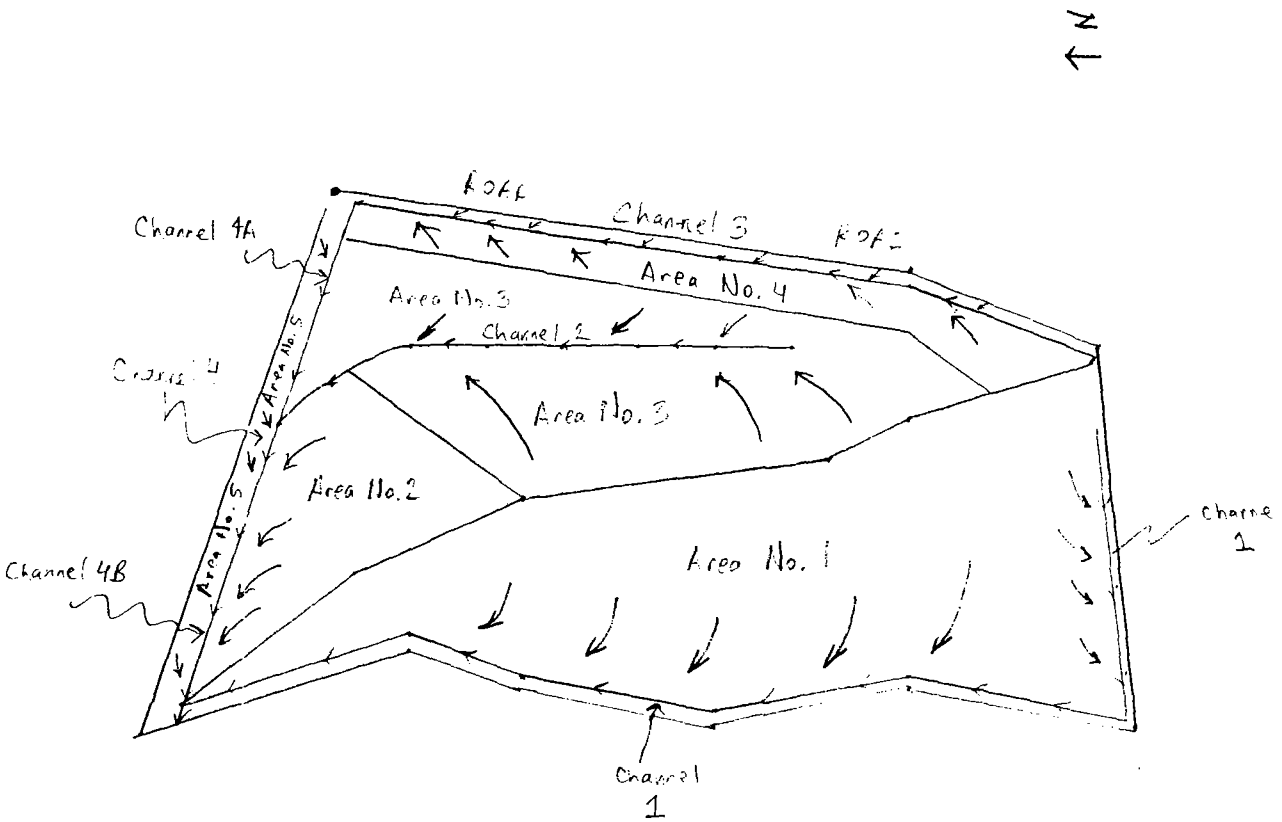
The surface of the SBPA final cover will consist of a top layer of low permeable asphalt. Stormwater runoff occurring along the northern and western parts of the watershed area will be collected by the existing and newly installed catch basins and conveyed through the SBPA stormwater collection system to concrete settling basins. The SBPA was partitioned into four sections based on the final design contours of the engineered cover. A sketch diagram has been provided illustrating the partitioning of the SBPA final cover used in this part of the evaluation. Below is a table summarizing the peak discharge rate results from each partitioned area.

Partitioned Area	Approximate Size (acres)	Peak Discharge Rate (cfs)
1	0.60	6
2	0.20	2
3	0.60	6
4	1.50	16

MONTGOMERY WATSON

BY Griesemer DATE 5/7/99 CLIENT ______ SHEET ______ OF ______

CHKD. BY ______ DESCRIPTION ACS 95% Design JOB NO. 1252042.28350101



Not to Scale

MONTGOMERY WATSON

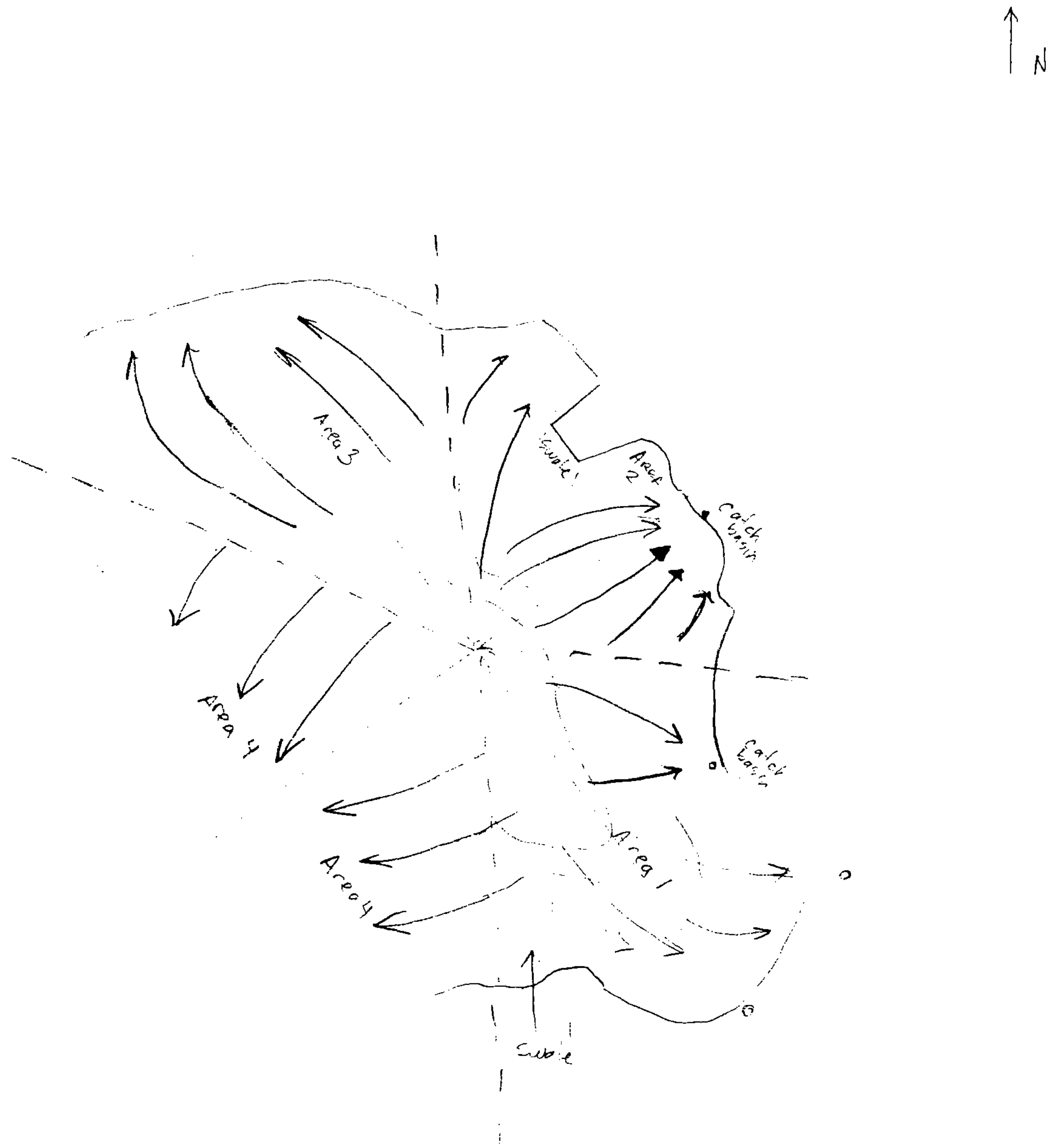
BY Griesemer DATE 5/7/99 CLIENT ACS SHEET ____ OF ____
CHKD. BY ____ DESCRIPTION ACS 95% Design JOB NO. 1252042.28350101

Channel	Maximum (cfs)	Contributors
1	13	Area 1
4B	31	Area 2 + Channel 4A + Channel 3 + Area 5B + Channel 2
4A	8	Area 5A + Channel 3
3	7	Roof + Area No. 4
2	14	Area 3

MONTGOMERY WATSON

BY Griesemer DATE 5/7/99 CLIENT ______ SHEET ______ OF ______

CHKD. BY ______ DESCRIPTION SBPA - Surface Water Drainage JOB NO. [illegible]



Not to Scale

EN 1S (10/78)

OFCA TR-55

MODEL RESULTS

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : ACS User: BPG Date: 04-01-99

County : Lake State: IN Checked: ____ Date: ________

Subtitle: 95% Final Design

Subarea : Off-1

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Poor condition; grass cover < 50%	4.25(68)	-	-	-
Total Area (by Hydrologic Soil Group)	4.25			
	====			

SUBAREA: Off-1 TOTAL DRAINAGE AREA: 4.25 Acres WEIGHTED CURVE NUMBER: 68

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : ACS User: BPG Date: 04-01-99

County : Lake State: IN Checked: ____ Date: ________

Subtitle: 95% Final Design

Subarea : Off-2

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Poor condition; grass cover < 50%	2.02(68)	-	-	-
Total Area (by Hydrologic Soil Group)	2.02			
	====			

SUBAREA: Off-2 TOTAL DRAINAGE AREA: 2.02 Acres WEIGHTED CURVE NUMBER: 68

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : ACS User: BPG Date: 04-01-99
County : Lake State: IN Checked: ____ Date: ________
Subtitle: 95% Final Design
Subarea : Off-3

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Poor condition: grass cover < 50%	3.31(68)	-	-	-
Total Area (by Hydrologic Soil Group)	3.31			
	====			

SUBAREA: Off-3 TOTAL DRAINAGE AREA: 3.31 Acres WEIGHTED CURVE NUMBER: 68

RUNOFF CURVE NUMBER COMPUTATION   Version 2.00

Project : ACS   User: BPG   Date: 04-01-99
County : Lake   State: IN   Checked: ____   Date: ________
Subtitle: 95% Final Design
Subarea : Off-4

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Poor condition; grass cover < 50%	1.78(68)	-	-	-
Total Area (by Hydrologic Soil Group)	1.78			

SUBAREA: Off-4   TOTAL DRAINAGE AREA: 1.78 Acres   WEIGHTED CURVE NUMBER: 68

RUNOFF CURVE NUMBER COMPUTATION   Version 2.00

Project : ACS   User: BPG   Date: 04-01-99
County : Lake   State: IN   Checked: ____   Date: ________
Subtitle: 95% Final Design
Subarea : Off-5A

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Poor condition; grass cover < 50%	0.28(68)	-	-	-
Total Area (by Hydrologic Soil Group)	.28			

SUBAREA: Off-5A TOTAL DRAINAGE AREA: .28 Acres   WEIGHTED CURVE NUMBER: 68

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : ACS User: BPG Date: 04-01-99
County : Lake State: IN Checked: ____ Date: ________
Subtitle: 95% Final Design
Subarea : Off-5B

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Poor condition; grass cover < 50%	0.34(68)	-	-	-
Total Area (by Hydrologic Soil Group)	.34 ====			

SUBAREA: Off-5B TOTAL DRAINAGE AREA: .34 Acres WEIGHTED CURVE NUMBER: 68

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : ACS User: BPG Date: 04-01-99
County : Lake State: IN Checked: ____ Date: ________
Subtitle: 95% Final Design

Subarea #1 - Off-1

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	4.5	300	0.035	e					0.265
Open Channel		1350	0.015		0.036		10.3		0.088
						Time of Concentration =			0.35*
									=====
Open Channel		1350	0.015		0.036		10.3		0.088
							Travel Time =		0.09*
									=====

Subarea #2 - Off-2

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	4.5	300	0.035	e					0.265
Open Channel		400	0.015		0.038.75		12.3		0.023
						Time of Concentration =			0.29*
									=====
Open Channel		450	0.015		0.038.75		12.3		0.026
							Travel Time =		0.03*
									=====

Subarea #3 - Off-3

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	4.5	200	0.030	e					0.204
Open Channel		470	0.015		0.036		10.3		0.031
						Time of Concentration =			0.23*
									=====
Open Channel		470	0.015		0.036		10.3		0.031
							Travel Time =		0.03*
									=====

* - Generated for use by TABULAR method

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : ACS User: BPG Date: 04-01-99
County : Lake State: IN Checked: ____ Date: ________
Subtitle: 95% Final Design

------------------------------ Subarea #4 - Off-4 ------------------------------

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	4.5	100	0.035	e					0.110
Open Channel		750	0.015		0.036		10.3		0.049
					Time of Concentration =				0.16*
Open Channel		750	0.015		0.036		10.3		0.049
							Travel Time =		0.05*

------------------------------ Subarea #5 - Off-5A ------------------------------

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	4.5	30	0.01	e					0.069
Open Channel		350	0.015		0.036		10.3		0.023
					Time of Concentration =				0.09*
Open Channel		350	0.015		0.036		10.3		0.023
							Travel Time =		0.02*

------------------------------ Subarea #6 - Off-5B ------------------------------

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	4.5	30	.01	e					0.069
Open Channel		350	0.015		0.038.75		12.3		0.020
					Time of Concentration =				0.09*
Open Channel		350	0.015		0.038.75		12.3		0.020
							Travel Time =		0.02*

--- Sheet Flow Surface Codes ---

A Smooth Surface	F Grass, Dense	--- Shallow Concentrated ---
B Fallow (No Res.)	G Grass, Burmuda	--- Surface Codes ---
C Cultivated < 20 % Res.	H Woods, Light	P Paved
D Cultivated > 20 % Res.	I Woods, Dense	U Unpaved
E Grass-Range, Short	J Range, Natural	

* - Generated for use by TABULAR method

TABULAR HYDROGRAPH METHOD Version 2.00

Project : ACS User: BPG Date: 04-01-99
County : Lake State: IN Checked: ____ Date: ________
Subtitle: 95% Final Design

Total watershed area: 0.019 sq mi Rainfall type: II Frequency: 100 years

	Subareas					
	Off-1	Off-2	Off-3	Off-4	Off-5A	Off-5B
Area(sq mi)	0.01*	0.00*	0.01*	0.00*	0.00*	0.00*
Rainfall(in)	7.0	7.0	7.0	7.0	7.0	7.0
Curve number	68*	68*	68*	68*	68*	68*
Runoff(in)	3.41	3.41	3.41	3.41	3.41	3.41
Tc (hrs)	0.35*	0.29*	0.23*	0.16*	0.09*	0.09*
(Used)	0.30	0.30	0.20	0.20	0.10	0.10
TimeToOutlet	0.00	0.00	0.00	0.00	0.00	0.00
Ia/P	0.13	0.13	0.13	0.13	0.13	0.13

Time	Total	Subarea Contribution to Total Flow (cfs)					
(hr)	Flow	Off-1	Off-2	Off-3	Off-4	Off-5A	Off-5B
11.0	0	0	0	0	0	0	0
11.3	1	1	0	0	0	0	0
11.6	2	1	0	1	0	0	0
11.9	9	2	1	3	2	0	1
12.0	18	5	2	6	3	1P	1
12.1	35	9	4	12	7P	1	2P
12.2	45P	15P	7P	14P	7	1	1
12.3	36	15	7	9	5	0	0
12.4	21	10	5	4	2	0	0
12.5	14	6	3	3	2	0	0
12.6	10	5	2	2	1	0	0
12.7	8	3	2	2	1	0	0
12.8	7	3	1	2	1	0	0
13.0	5	2	1	1	1	0	0
13.2	5	2	1	1	1	0	0
13.4	4	1	1	1	1	0	0
13.6	3	1	1	1	0	0	0
13.8	3	1	1	1	0	0	0
14.0	2	1	0	1	0	0	0
14.3	2	1	0	1	0	0	0
14.6	2	1	0	1	0	0	0
15.0	2	1	0	1	0	0	0
15.5	2	1	0	1	0	0	0
16.0	1	1	0	0	0	0	0
16.5	1	1	0	0	0	0	0
17.0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0

P - Peak Flow * - value(s) provided from TR-55 system routines

SBPA TR-55

MODEL RESULTS

RUNOFF CURVE NUMBER COMPUTATION — Version 2.00

Project : ACS — User: BPG — Date: 04-01-99
County : Lake — State: IN — Checked: ____ — Date: ________
Subtitle: 95% Final Design
Subarea : On-1

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Impervious Areas				
Paved parking lots, roofs, driveways	0.6(98)	-	-	-
Total Area (by Hydrologic Soil Group)	.6 ====			

SUBAREA: On-1 TOTAL DRAINAGE AREA: .6 Acres WEIGHTED CURVE NUMBER: 98

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : ACS User: BPG Date: 04-01-99
County : Lake State: IN Checked: ____ Date: ________
Subtitle: 95% Final Design
Subarea : On-2

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Impervious Areas				
Paved parking lots, roofs, driveways	0.2(98)	-	-	-
Total Area (by Hydrologic Soil Group)	.2 ====			

SUBAREA: On-2 TOTAL DRAINAGE AREA: .2 Acres WEIGHTED CURVE NUMBER: 98

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : ACS User: BPG Date: 04-01-99
County : Lake State: IN Checked: ____ Date: ________
Subtitle: 95% Final Design
Subarea : On-3

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Impervious Areas				
Paved parking lots, roofs, driveways	0.6(98)	-	-	-
Total Area (by Hydrologic Soil Group)	.6 ====			

SUBAREA: On-3 TOTAL DRAINAGE AREA: .6 Acres WEIGHTED CURVE NUMBER: 98

```
                        RUNOFF CURVE NUMBER COMPUTATION              Version 2.00
Project : ACS                                      User: BPG       Date: 04-01-99
County  : Lake                  State: IN       Checked: ____      Date: ________
Subtitle: 95% Final Design
Subarea : On-4
-------------------------------------------------------------------------------
                                                       Hydrologic Soil Group
         COVER DESCRIPTION                          A        B        C        D
                                                           Acres (CN)
-------------------------------------------------------------------------------
FULLY DEVELOPED URBAN AREAS (Veg Estab.)
Impervious Areas
  Paved parking lots, roofs, driveways        1.5(98)       -        -        -


Total Area (by Hydrologic Soil Group)         1.5
                                             ====

-------------------------------------------------------------------------------
SUBAREA: On-4   TOTAL DRAINAGE AREA: 1.5 Acres       WEIGHTED CURVE NUMBER: 98
-------------------------------------------------------------------------------
```

TIME OF CONCENTRATION AND TRAVEL TIME — Version 2.00

Project : ACS — User: BPG — Date: 04-01-99

County : Lake — State: IN — Checked: ____ — Date: ________

Subtitle: 95% Final Design

Subarea #1 - On-1

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Shallow Concent'd	300	0.02	p					0.029
							Time of Concentration =	0.03*
Shallow Concent'd	300	0.02	p					0.029
							Travel Time =	0.03*

Subarea #2 - On-2

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Shallow Concent'd	300	0.02	p					0.029
							Time of Concentration =	0.03*
Shallow Concent'd	300	0.02	p					0.029
							Travel Time =	0.03*

Subarea #3 - On-3

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Shallow Concent'd	300	0.02	p					0.029
							Time of Concentration =	0.03*
Shallow Concent'd	300	0.02	p					0.029
							Travel Time =	0.03*

* - Generated for use by TABULAR method

```
                         TIME OF CONCENTRATION AND TRAVEL TIME          Version 2.00
Project : ACS                                           User: BPG       Date: 04-01-99
County  : Lake                       State: IN     Checked: ____        Date: ________
Subtitle: 95% Final Design

------------------------------ Subarea #4 - On-4 ------------------------------
Flow Type                Length  Slope  Surface  n   Area     Wp   Velocity  Time
                          (ft)  (ft/ft)  code       (sq/ft)  (ft)  (ft/sec)  (hr)
-------------------------------------------------------------------------------
Shallow Concent'd         300    0.02     p                                 0.029
                                                       Time of Concentration = 0.03*
                                                                              =====

Shallow Concent'd         300    .02      p                                 0.029
                                                                 Travel Time = 0.03*
                                                                              =====

        --- Sheet Flow Surface Codes ---
    A Smooth Surface            F Grass, Dense     --- Shallow Concentrated ---
    B Fallow (No Res.)          G Grass, Burmuda   ---     Surface Codes    ---
    C Cultivated < 20 % Res.    H Woods, Light               P Paved
    D Cultivated > 20 % Res.    I Woods, Dense               U Unpaved
    E Grass-Range, Short        J Range, Natural
* - Generated for use by TABULAR method
```

TABULAR HYDROGRAPH METHOD Version 2.00

Project : ACS User: BPG Date: 04-01-99
County : Lake State: IN Checked: ____ Date: ________
Subtitle: 95% Final Design

Total watershed area: 0.005 sq mi Rainfall type: II Frequency: 100 years

	Subareas			
	On-1	On-2	On-3	On-4
Area(sq mi)	0.00*	0.00*	0.00*	0.00*
Rainfall(in)	7.0	7.0	7.0	7.0
Curve number	98*	98*	98*	98*
Runoff(in)	6.76	6.76	6.76	6.76
Tc (hrs)	0.03*	0.03*	0.03*	0.03*
(Used)	0.10	0.10	0.10	0.10
TimeToOutlet	0.00	0.00	0.00	0.00
Ia/P	0.01	0.01	0.01	0.01
(Used)	0.10	0.10	0.10	0.10

Time	Total	Subarea Contribution to Total Flow (cfs)			
(hr)	Flow	On-1	On-2	On-3	On-4
11.0	0	0	0	0	0
11.3	1	0	0	0	1
11.6	1	0	0	0	1
11.9	10	2	1	2	5
12.0	19	4	1	4	10
12.1	30P	6P	2P	6P	16P
12.2	19	4	1	4	10
12.3	5	1	0	1	3
12.4	4	1	0	1	2
12.5	4	1	0	1	2
12.6	4	1	0	1	2
12.7	3	1	0	1	1
12.8	1	0	0	0	1
13.0	1	0	0	0	1
13.2	1	0	0	0	1
13.4	1	0	0	0	1
13.6	1	0	0	0	1
13.8	1	0	0	0	1
14.0	1	0	0	0	1
14.3	1	0	0	0	1
14.6	1	0	0	0	1
15.0	0	0	0	0	0
15.5	0	0	0	0	0
16.0	0	0	0	0	0
16.5	0	0	0	0	0
17.0	0	0	0	0	0
17.5	0	0	0	0	0
18.0	0	0	0	0	0
19.0	0	0	0	0	0
20.0	0	0	0	0	0
22.0	0	0	0	0	0
26.0	0	0	0	0	0

P - Peak Flow   * - value(s) provided from TR-55 system routines

F

Geotextile Puncture and Burst Resistance Calculations

MONTGOMERY WATSON

BY Griesemer DATE 5/19/99 CLIENT ACS SHEET ______ OF ____
CHKD. BY SJS DESCRIPTION Burst Resistance Calculations JOB NO. 1252042.28350101

- Calculations are being conducted or selected geotextiles against possible failure conditions. We have designed the OFCA and SBPA engineered covers with a geotextile layer. The geotextile layer will be placed on a soil subgrade with stone of average particle diameter placed above geotextile. The geotextile material layer is polyester, non-woven, and needle punched.

Subgrade: 6.0" Largest Rock Size

Cover ... : 2.0" Largest Rock Size

Heaviest Load: 100 psi - (Heavy truck conservative)

Geotextile Min: Burst = 780 psi, Puncture = 195 lbs

0.149 = AOS

Burst Resistance (Geotextile)

$$FS_g = \frac{T_{allow}}{T_{req'd}} = \frac{(p_{test})(d_{test})}{(FS_p)\, p'\, d_v}$$

p_{test} = burst test pressure
d_{test} = diameter of burst test device (= 1.2m) (Mullen)
p' = stress on geotextile surface ≤ tire inflation
d_v = maximum void diameter (2 stones next to each other ≈ $0.33 d_a$)
d_a = average stone diameter
FS_p = partial factor of safety, use 1.5

$$FS_g = \frac{(780)(1.2)}{(1.5)(100)(0.33)(2.0)} = 9.5 > 2.0 \text{ Acceptable}$$

$FS_{g\,(subgrade)}$ =

$$FS_g = \frac{T_{allow}}{T_{req'd}} = \frac{(780)(1.2)}{(1.5)(100)(0.33)(6)} = 3.15 > 2.0 \text{ Acceptable}$$

MONTGOMERY WATSON

SHEET ______ OF ______

BY Griesemer DATE 5/19/99 CLIENT ACS JOB NO. 1252042.28350101

CHKD. BY SJS DESCRIPTION Puncture Calculations

Puncture (Geotextile)

$$F_{req'd} = p' \, d_a^2 \, S_1 S_2 S_3$$

$F_{req'd}$ = required vertical force

p' = pressure on geotextile (≈ 100% tire pressure)

d_a = average diameter of puncturing aggregate

hh = protrusion height ≤ d_a

S_1 = protrusion factor = hh/d_a

S_2 = scale factor = $0.31/d_a$

S_3 = shape factor = $1 - A_p/A_c$

A_p = projected area of particle

A_c = area of smallest circumscribed Area

Use 0.5 for A_p/A_c for some angular debris

$$F_{req'd} = (100)(2)^2 \left(\frac{0.67}{2}\right)\left(\frac{0.31}{2}\right)(1-0.5) \approx 10.4 \text{ lb}$$

$$FS_{global} = \frac{F_{allow} / F.S._{part}}{F_{req'd}} = \frac{195/2.0}{10.4} = 9.4 \text{ Acceptable } (>2)$$

G

MONTGOMERY WATSON

August 13, 1999

Mr. Kevin Adler
Remedial Project Manager
U.S. Environmental Protection Agency
Region V, SR-J6
77 West Jackson Blvd.
Chicago, IL 60604

Re: Responses to Agency Review Comments on 95% RD
ACS NPL Site, Griffith, Indiana

Dear Mr. Adler:

We received two sets of Agency review comments on the May 21, 1999 95 Percent Remedial Design (RD) Report for the Final Remedy at the ACS NPL Site in Griffith, Indiana. These include the June 16, 1999 Comment Letter from Black and Veatch Special Projects Contract (BVSPC, on behalf of the U.S. EPA) and the July 8, 1999 Comment Letter from the Indiana Department of Environmental Management (IDEM).

We understand that it is U.S. EPA's objective to receive the Final (100 Percent) RD Report before the end of August 1999, so that it can be included as the Statement of Work (SOW) in the Consent Decree currently being negotiated among the U.S. EPA, IDEM, and the members of the ACS RD/RA Group. To facilitate the timely completion of the Final RD document, Montgomery Watson met with U.S. EPA, BVSPC, and IDEM on July 29, 1999 to discuss the Agency comments and reach consensus on the appropriate and acceptable response for each one.

The purpose of this letter is to summarize the ACS RD/RA Group's response to each of the comments for the Final Design, based on the discussions with U.S. EPA and IDEM at the July 29 meeting. We expect to complete the Final RD Report for submittal to the U.S. EPA on August 20, 1999. To facilitate the completion and submittal of an approvable document, we are providing in advance, the following summary of modifications that we are making in the final document, in response to the U.S. EPA and IDEM comments. If any of these responses are not in accordance with your understanding of the consensus at the July 29 meeting, please let us know immediately.

In the sections below, we first list the Agency comment and then provide the response.

2100 Corporate Drive
Addison, Illinois
60101

Tel: 630 691 5000
Fax: 630 691 5133

RESPONSE TO COMMENTS ON JULY 16, 1999 LETTER

Comment G1. Section 1.0, Page 1: BVSPC recommends the preparation of complete documents and supporting documents to ensure that USEPA, as well as the potentially responsible parties (PRPs), have an adequate ability to control and document the work in the field. It was presumed that the 95% design submitted document is only for USEPA conceptual design approval purposes, and that detailed construction plans, specifications, construction quality assurance plan, operation and maintenance plan, closure plan, and post-closure plan will be prepared following the approval of this conceptual design. In spite of the significant work performed to-date, there is clearly significant detailed design work yet to be accomplished. The design build format anticipated does not relieve the PRPs of their responsibility to properly document and verify the locations, dimensions, criteria, and standards under which the work will be built.

Comment G2. BVSPC recommends providing references to specific drawings for clarity due to the numerous activities and complexity of details. Throughout this document no reference to specific drawings are provided, only reference to "... shown on Drawings..." is indicated.

Comment G3. Section 5: BVSPC recommends indicating appropriate QA/QC that will be used in the field for cover installations. It is presumed that will be covered when detailed construction documents are prepared. It is furthered assumed that all barrier layers (compacted clay layers in caps and slurry walls) will be constructed as required in regard to permeability, also documented by the detailed plans and specifications yet to be prepared.

Comment G4. Drawings: Other drawings such as electrical, utilities, etc. are presumed to be provided with the final construction plans.

Response to comments G1 through G4
As discussed at our July 29 meeting, the Remedial Design/Remedial Action (RD/RA) for the ACS project has been developed to follow the design/build project delivery system. Individual request-for-bid (RFB) packages will be prepared for each component of the final remedy. These RFB packages will include design drawings and specifications, which detail the Agency-approved concepts in the Final RD document, along with contract conditions and other relevant information. Once bids are received and a subcontractor is selected for each component, detailed shop drawings for that component will be submitted to Montgomery Watson by the subcontractor for approval. Following revisions, re-submittals, if necessary, and approval by Montgomery Watson, the shop drawings and the detail drawings and specifications included in the RFB packages will be forwarded to BVSPC for their use. These will form the basis for oversight and inspection of the subcontractors' work. As-built drawings will be developed following successful completion of the project, and submitted to the Agencies to document compliance with the Agency-approved design.

Comment S1. Section 1.4, Page 5: For clarity, BVSPC recommends providing references to documents (i.e., 30% Design) which define and clarify specific concentration, levels, and areas of contaminants. Also reference to relative local condition documentation (e.g., site geology) is recommended general clarity of existing site conditions.

Response to Comment S1

The 30% Remedial Design Report has been referenced to define and clarify specific concentration, levels, and areas of contaminants. The following citation will be added to the References and used to clarify physical setting of the site, including the geology, in Section 1.4: "Remedial Investigation Report, ACS NPL Site, Griffith, Indiana, Warzyn, Inc., June 1991."

Comment S2. Section 3.3.1, Page 18, Paragraph 4, 3rd Sentence: Delete "were" for "Within the SBPA, were the ..."

Response to Comment S2

The word "were" has been deleted in Section 3.3.1.

Comment S3. Section 3.3.1, Page 18, Paragraph 5: Define that the location of sampling ports and control for each SVE well is in the process building and not at the well head.

Response to Comment S3

The second sentence in Paragraph 4, Section 3.3.1 has been revised to state: "Each wellhead will have a removable cover and each ISVE vapor conveyance pipe will have a sample port and throttling valve inside the respective blower shed."

Comment S4. Section 3.4, Page 21: If vapor treatment system is provided at the same location as the vacuum blower, then another blower will probably not be required to transport the vapor from the vacuum blower system to the treatment system.

Response to Comment S4

As stated in Section 3.4, the off-gas treatment system will be located at the groundwater treatment building while the ISVE blower will be located in a blower shed at the well field. The "Future ISVE Equipment" area shown in Drawing M-1 is for future expansion (the addition of a second ISVE blower) of the system during full-scale operation.

Comment S5. Section 3.5, Page 22: BVSPC recommends that the reference to the Performance Standard Verification Plan be defined in the introduction as part of the overview of the design-build process.

Response to Comment S5

The following sentence has been added to the first paragraph of the Introduction in Section 1, on page 1: "This Remedial Design should be used in conjunction with the following work plans, submitted in June 1999: Performance Standard Verification Plan, Construction Quality Assurance Plan, Field Sampling Plan Addendum, Site Safety Plan Addendum, and Contingency Plan."

Comment S6. Section 3.7.1, Page 27, 3rd Paragraph: BVSPC recommends defining the source of proposed asymptotic level approach (adopted from an accepted reference, an agreed-to approach between the PRPs and regulatory agencies, or just a proposed approach).

Response to Comment S6
Technical and management representatives of U.S. EPA, IDEM, BVSPC and the ACS Group met at the Northwest Regional Office of IDEM in Gary, Indiana on August 20, 1998. The purpose of the meeting was to reach conceptual agreement on the revised remedy for the ACS Site. Topics discussed and resolved included a number of issues including the implementation process and shut-off criteria for the ISVE systems. Therefore, the second sentence in Section 3.7.1 (Paragraph 3) has been revised to state: "As agreed upon in the August 20, 1998 design workshop meeting at the IDEM office in Gary, Indiana, the asymptotic level will be defined as less than a 2.5% change per quarter in the recovered vapor VOC concentration, as determined by three consecutive samples."

Comment S7. Section 3.7.3 Page 28: BVSPC's opinion is that the long-term vent criteria of "100 pounds or less" seems to be quite high. Considerable mass is still present at this level and significant removals that can be removed by SVE.

Response to Comment S7
To reference the consensus previously reached among the Agencies and the ACS Group, the first sentence in Section 3.7.3 has been revised to state: "Either continuous or cycled operation of the ISVE system, as described above, will continue in the OFCA, K-P Area, and SBPA until the total removal rate has been reduced to 100 pounds per day or less for all three ISVE systems as agreed upon during the August 20, 1998 design workshop meeting at the IDEM office in Gary, Indiana."

Comment S8. Section 4.1, Page 29: Define approximate initial water level or desired final dewatered water level for reference.

Response to Comment S8
Groundwater elevations in the Still Bottoms Pond Area (SBPA) and Off-Site Containment Area (OFCA) have historically been 634 feet above mean sea level (amsl), with an annual variability of less than two feet. The final desired de-watered groundwater level in the SBPA is 629 feet amsl. The final desired de-watered groundwater level in the OFCA is 626 feet amsl. Section 4.1 will be revised to incorporate this information and figures will be added to the Final RD Report to show initial and desired groundwater levels within the barrier wall and groundwater levels outside of the barrier wall.

Comment S9. Section 4.3.1, Page 31, 2nd Paragraph: Provide reference for previous pump test results.

Response to Comment S9

A pumping test was conducted on March 20 and 21, 1995 to evaluate the hydraulic characteristic of the unconfined (upper) aquifer for the design of the Perimeter Groundwater Containment System (PGCS). The test was conducted in accordance with the PGCS RD/RA Work Plan. The results of the drawdown analysis indicated that the maximum sustainable extraction rate for a single well is less than one gallon per minute (GPM) and the radius of influence for a single well is approximately 60 feet.

Comment S10. Section 4.3.5, Page 32: Define designation for in-line wells to correspond to drawings (e.g., Drawing C-2 for well EW-19, in-line well EW-19A; for EW-20, in-line wells EW-20A, -20B, -20C).

Response to Comment S10

The designation of the in-line wells will be defined in Section 4.3.5 of the Final RD.

Comment S11. Section 5.0, Page 33: Delete one of the "OFCA" designations from the first sentence.

Response to Comment S11

The duplicate "OFCA" has been deleted from the first sentence of Section 5.0.

Comment S12. Section 5.3.1, Page 36: Include additional bullet for geotextile layer.

Response to Comment S12

An additional bullet for the geotextile layer has been added to Section 5.3.1.

Comment S13. *Section 5.3.1, Page 36-37: BVSPC recommends that an O&M Plan be* submitted and approved to document the PRPs intentions in regard to the maintenance and rehabilitation of the asphalt pavement in the SBPA.

Response to Comment S13

An O&M Plan will be developed for the entire Site following submittal of the Final RD. A section of the O&M Plan will discuss the long-term maintenance and rehabilitation of the asphalt pavement in the SBPA.

Comment S14. Section 5.3.1.1, Page 37: Provide reference for USEPA-approval of asphalt covers at other CERCLA sites.

Response to Comment S14
The U.S. EPA has granted approval of alternative asphalt covers at the following sites:

- Hill Air Force Base, Utah
- G&H Landfill, Michigan
- Tri-County Landfill, Elgin, Illinois.

The text in Section 5.3.1.1 will be revised to reference these sites.

Comment S15. Section 5.3.2, Page 37: Provide permeability rating for FML liner.

Response to Comment S15
The hydraulic conductivity used for calculations regarding the FML liner is 4.0×10^{-13} cm/sec, as presented in the OFCA HELP Model results located in Appendix D. This is typical of most polyethylene FML liner specifications.

Comment S16. Section 5.5.2.3, Page 42: Provide referenced calculations made to select geosynthetic materials versus the required strengths and other criteria (e.g., layer stability, global stability, material strength, anchor trench design, etc.).

Response to Comment S16
Puncture and burst resistance calculations have been conducted on selected geosynthetic materials to demonstrate the selected geosynthetic material's suitability for their intended use(s). The referenced calculations have been added to the Final RD.

Comment S17. Section 6.0, Page 43: Location of MW-9 referenced, but not identified on drawings.

Response to Comment S17
Monitoring well MW-9 has been abandoned and replaced by MW-9R. Monitoring well MW9R has been added to Drawing C-1.

Comment S18. Sections 6.1.1 and 6.1.2, Pages 44 and 45. BVSPC's opinion is that use of MNA and techniques such as ORC often is not very successful for areas with high contaminant mass concentrations of benzene in the range of 5-10 mg/L.

Response to Comment S18
The ORC pilot study was started in March 1999 and will continue until March 2000. Further measurements will be taken to determine its effectiveness in the North Area and reported upon completion of the study. Concentrations of benzene within the ORC pilot study were historically approximately 10 mg/L (10 ppm). Immediately prior to the ORC injections, the benzene concentrations were on the order of 1-2 ppm. Data collected during the first three months of the study appear to indicate that the benzene concentrations are decreasing. Future sampling and analysis in the ORC area will determine its effectiveness in accelerating the biodegradation of contaminants in the groundwater.

Comment A1. Drawing G-3: Provide project specific abbreviations used on other drawings (e.g. Drawing c-16 uses abbreviations for OFCA, FML, VFPE)

Response to Comment A1
The Acronyms List on Page vii of the Executive Summary of the Final RD Report has been cross-referenced on Drawing G-3 to provide project-specific abbreviations.

Comment A2. Drawing C-1: Boldface print for the Cover and ISVE in Offsite Containment Area, since this feature is currently not existing.

Response to Comment A2
The text has been boldfaced as recommended on Drawing C-1.

Comment A3. Drawing C-1: Use lighter line around PCB-impacted soil area, since the bold line indicated a barrier wall.

Response to Comment A3
A lighter line around the PCB-impacted soil area has been utilized on Drawing C-1.

Comment A4. Drawing C-1: Provide north arrow.

Response to Comment A4
A north arrow has been provided on Drawing C-1.

Comment A5. Drawing C-2: Correct call-out designation and description on legend for inline wells (3rd designation listed).

Response to Comment A5
The call-out designation and description on the legend for inline wells has been corrected on Drawing C-2.

Comment A6. Drawing C-2: Provide call-outs for new barriers near well EW-15.

Response to Comment A6
The only new barrier is the separation barrier wall. This comment was addressed and resolved during the meeting on July 29, 1999. The figure will not be changed in the Final RD.

Comment A7. Drawing C-2: Define termination point of conveyance pipe as "Groundwater Treatment Plant."

Response to Comment A7
The termination point of the conveyance pipe has been defined as the "Groundwater Treatment Plant" on Drawing C-2.

Comment A8. Drawings C-3 through C-14: Control points (existing benchmarks) and existing grade contours not well defined.

Response to Comment A8
Control points will be added on Drawing C-2, C-3, and C-9. Prior to construction activities, existing contours will be field verified.

Comment A9. Drawing C-5: Define call-out for detail "Detail 3, Drawing C-18" on Drawing C-18.

Response to Comment A9
The call out for detail "Detail 3, Drawing C-18" on Drawing C-18 has been defined on Drawing C-5.

Comment A10. Drawing C-9A: Define approximate final drainage area grade elevations.

Response to Comment A10
On Drawing C-9A, due to continued Site maintenance conducted by ACS, approximate final drainage area grade elevations can not be defined, since activities such as road grading change the conditions. Montgomery Watson will field verify the final drainage contours during the remedial action construction phase and will subsequently provide this information in the as-built drawings.

Comment A11. Drawing C-12: Define call-out for "Detail 1, Drawing C-17" on Drawing C-17.

Response to Comment A11
The call out for "Detail 1, Drawing C-17" on Drawing C-17 has been defined on Drawing C-12.

Comment A12. Drawing C-13: Define call-out for "Detail "1, Drawing C-18" on Drawing C-18.

Response to Comment A12
The call out for "Detail 1, Drawing C-18" on Drawing C-18 has been defined on Drawing C-13.

Comment A13. Drawing C-16, Section A: Delete call-outs for Drawings C-4 and C-7 or define this section on those drawings.

Response to Comment A13
The call outs for Drawings C-4 and C-7 have been deleted on Drawing C-16, Section A.

Comment A14. Drawing C-16, Section B: Delete call-out for Drawing C-7 or define this section on that drawing.

Response to comment A14
The call out for Drawing C-7 has been deleted on Drawing C-16, Section B.

Comment A15. Drawing C-17, Detail 1: See comment A11.

Response to Comment A15
This comment has been addressed by responding to comment A11.

Comment A16. Drawing C-18, Detail 3: See comment A9.

Response to Comment A16
This comment has been addressed by responding to comment A9.

Comment A17. Drawing C-18, Detail 1: See comment A12.

Response to Comment A17
This comment has been addressed by responding to comment A12.

Comment A18. Drawing C-18, Section D: Section not shown on Figure C-13.

Response to Comment A18
Drawing C-18, Section D has been shown on Drawing C-13.

Comment A19. Drawing C-19, Section B, Note 1: Define "Sheet" referenced.

Response to Comment A19
On Drawing C-19, Section B, Note 1, Sheet C-16 has been referenced.

Comment A20. Drawing C-19, Section E: Provide a note similar to Section B, Note 3 regarding burial depth of water conveyance lines.

Response to Comment A20
On Drawing C-19, Section E, the following note has been provided regarding burial depth of water conveyance lines: "All pipes conveying groundwater or condensate must have a final minimum buried depth of 42 to the top of pipe."

Comment B1. Page 1: Provide reference to 30% Design as basis of mass calculations (Appendix A) and ISVE modeling results (Appendix B).

Response to Comment B1
The 30% Remedial Design document has been referenced on page 1 on the ISVE Design Memorandum.

Comment B2. Page 3 (Number of Wells): For clarity list number of basic ISVE wells versus number of dual extraction wells within 3rd bullet.

Response to Comment B2
The number of basic ISVE wells (67) versus the number of dual extraction wells (21) has been listed for clarity on Page 3 of the ISVE Design Memorandum.

Comment B3. Page 4 (Paragraph 1 and Paragraph 4): Capital cost or running individual lines versus monitoring control cost appears excessive in related to running individual lines from each SVE well to the treatment building.

Response to Comment B3
Because of the relatively low cost of HDPE piping and the fact that many conveyance lines can be placed in a single trench, running individual lines back to the ISVE blower shed is

believed to be as cost-effective and more operator-friendly than designing a multiple header system with manifold from each section of ISVE well field. By installing individual pipes from each ISVE well, control of vapor flow from each well can be performed in one centralized location (blower shed).

Comment B4. Page 5-6 (Dual phase extraction well design): For continuity, suggest moving this section to page 4 to follow ISVE well construction details.

Response to Comment B4

As recommended, the dual phase extraction well design section has been moved to follow the ISVE well construction details section.

Comment B5. Page 5 (Dual phase extraction well design): Provide specific reference for dewatering calculations.

Response to Comment B5

Appendix C has been referenced for de-watering calculations.

Comment B6. Pages 6-7: Provide general statement regarding planned design for SVE blower, condensate pump, and catalytic oxidizer for SBPA.

Response to Comment B6

The following sentences will be added as an introduction to the ISVE mechanical (blower, condensate pump, catalytic oxidizer, scrubber) discussion: "Design and installation of the ISVE system will be implemented in stages. The initial OFCA and K-P ISVE system will consist of a single blower and off-gas treatment system. Following start-up of the OFCA and K-P initial systems, the system will be upgraded, as necessary, to operate at full-scale. The SBPA system will be similarly started-up in phases."

Comment B7. Page 6: Provide the following referenced calculations, which are not attached to this Appendix:

ISVE Blower pressure drop calculations.
Condensate Pump condensate flow calculations.
Catalytic Oxidizer calculations.
Scrubber calculations.

Response to Comment B7

The ISVE blower pressure drop and condensate pump/condensate flow calculations have been provided in the Final RD Report as an attachment to Appendix B. Because individual off-gas treatment manufacturers have differing procedures to calculate sizing and efficiencies for their units, the catalytic oxidizer and scrubber calculations will be submitted with shop drawings and specifications following procurement of the off-gas treatment system.

Comment C1. Page 1, Bullet 1: Dewatering level for the off-site containment area is defined in Section 4.1, Page 29, as 5 feet and 8 feet in bullet one. Clarify which level is correct.

Response to Comment C1
The water level in the On-Site Area (and SBPA) will be lowered eight feet. Page 29 of the Final RD Report includes this number.

Comment C2. Calculations: Provide summary of information used from 30% Design. Due to the multiple scenarios and corrections to the calculations in Appendix C - Dewatering Calculations of the 30% Design, it is hard to follow exactly.

Response to Comment C2
Information used in the calculations from the 30% RD will be included in the Final RD, and the calculations in Appendix C will be expanded for clarity in the Final RD.

RESPONSE TO SPECIFIC COMMENTS IN IDEM'S JULY 8, 1999 LETTER

Page 3, Section 1.2: The contractor refers to off-site groundwater contamination "in the northeast portion outside the barrier wall . . . " It is assumed that the contractor is referring to the groundwater contaminant plume that exists to the north and northwest of the site, outside the barrier wall.

Response to Comment 1
The off-site groundwater contamination "in the northeast portion outside the barrier wall..." does refer to the groundwater contaminant plume that exists to the north and northwest of the Site, outside of the barrier wall. This will be clarified in the text.

Page 28, Section 3.7.3: The contractor states "Either continuous or cycled operation of the ISVE system, as described above, will continue in the OFCA(,) K-P Area(,) and SBPA until the respective removal rate has been reduced to 100 pounds per day or less." This statement is ambiguous. It should be made clear that the removal rate of less than 100 pounds of VOCs is for all of the areas combined. That is, total VOCs for the OFCA and the K-P Area and the SBPA combined must be less than 100 pounds per day for system shutdown. If the 100 pound per day limit was for each ISVE area, the smaller areas with fewer extraction wells, such as the K-P Area, could quickly reach the 100 pound per day limit. Also, because the 100 pound per day limit is intended to "correspond roughly with the estimated initial removal rate of the groundwater treatment system" the entire ISVE system should be used in evaluating the 100 pound per day cut-off criterion.

Response to Comment 2

As stated in U.S. EPA response to Comment S7 (page 4 of this letter), the total VOCs for the OFCA, K-P Area, and the SBPA combined will be less than 100 pounds per day for ISVE system shutdown as discussed in the August 20, 1998 design workshop meeting at IDEM's office in Gary, Indiana.

Page 28, Section 3.7.3: The contractor states " . . . groundwater will be pumped to the groundwater treatment plant at a pumping rate sufficient to maintain a level that will not allow groundwater to overflow the barrier wall or to maintain an inward gradient where *possible. This groundwater level will be the maintenance level." This is unclear.* Obviously, the groundwater levels should never be allowed to overtop any section of the barrier wall, but maintaining levels to prevent overtopping is not the same as maintaining an inward head gradient. Because of the need for ISVE dewatering, the pumping capacity in place should be sufficient to maintain an inward head boundary within the barrier wall. The top elevation of the barrier wall varies with surface elevation, and because the site will be separated into two areas by a "separation barrier wall" it is possible for the groundwater levels to be maintained at two different levels for the two separate areas. The contractor should provide a more detailed discussion of the anticipated ground water maintenance levels, how they compare with the top elevation of the barrier wall at its lowest elevation, and how the groundwater levels within the barrier wall will compare to groundwater levels outside the wall. A detailed description or map should be included indicating the areas where the gradient will be inward across the barrier wall and areas where the gradient will be outward.

Response to Comment 3

The approximate water level in the On-Site Area (including the SBPA), based on historical groundwater level data, is 634 feet amsl and final desired de-watered groundwater level for ISVE treatment in the SBPA is 626 feet amsl. The approximate water level in the Off-Site Area, based on historical groundwater level data, is also 634 feet amsl and final desired de-watered groundwater level in the Off-Site Area for ISVE treatment is 629 feet amsl. Section 4.1 will be revised to incorporate this information and figures will be added to the Final RD Report to show initial and desired groundwater levels within the barrier wall and historic groundwater levels outside of the barrier wall.

Page 29, Section 4.0: In this section, the contractor discusses the flow requirements of the groundwater treatment system and states "In addition, the groundwater extraction system and treatment plant must also allow for continued operation of the PGCS and flexibility of routing the influent sources to either the pretreatment or main treatment systems depending upon contaminant levels and flow rates." On page 45 (Section 6.1.1) the contractor mentions that if ORC applications fail to adequately remediate the north plume, the PGCS could be expanded to capture the source area of the plume. The treatment system upgrade design must also have the capacity to handle treatment of an expanded PGCS. This should be explicitly addressed in the document.

Response to Comment 4

The groundwater treatment plant upgrade was not designed to handle treatment of an expanded PGCS. If necessary, the treatment system could be expanded. However, due to the nature of the contamination (primarily benzene and chloroethane), if treatment in the PGCS area was necessary, a small treatment unit, such as an air stripper, may be a cost-effective alternative to upgrading the entire groundwater treatment plant.

We are currently revising the 95 Percent RD Report in accordance with the above responses. We are planning to send the Final RD Report to you on August 20, 1999. If you have questions regarding our responses, please contact me at (630) 691-5045.

Sincerely,

MONTGOMERY WATSON

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